SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM ASSESSMENT PROJECT FINAL REPORT

GRASS, ENOS, AND LEFT HAND CREEK NONPOINT SOURCE REDUCTION PROJECT PHASE II: Using Cooperative Grazing Management to Reduce Sediment Loading and Improve Riparian and Aquatic Habitat
PROJECT NO. NPS2011B

by

The Nature Conservancy
NW Wyoming Program
Cody, Wyoming

January 2016

This project was conducted in cooperation with the State of Wyoming Department of Environmental Quality, United States Environmental Protection Agency Region 8, Natural Resource Conservation Service, Bureau of Land Management, and the LU Ranch.

Grant No.: C900863011

1.0 Executive Summary

PROJECT TITLE: GRASS, ENOS, AND LEFT HAND CREEK NONPOINT SOURCE REDUCTION PROJECT – II: Using Cooperative Grazing Management to Reduce Sediment Loading and Improve Riparian and Aquatic Habitat

PROJECT START DATE: Aug 16, 2011 PROJECT COMPLETION DATE: Dec. 31, 2015

Table 1: Project Budget Summary	
Total 319 or 205(j) Funds Awarded	$271,611.62
Total 319 or 205(j) Funds Expended	$271,611.61
Total Nonfederal Match Commitment	$131,637.47
Total Nonfederal Match Expended	$135,302.51
Total Project Budget	$403,249.09
Total Project Expenditures	$406,914.12

SUMMARY OF ACCOMPLISHMENTS:
Launched in 2008 with BMP implementation initiated in 2010, this project aims to reduce sediment loading and mean temperatures in project area streams, and to maintain or improve riparian and aquatic habitat through the implementation of livestock Best Management Practices (BMPs). All project goals were met in Phase II: project and administrative costs stayed within budget, goals for the implementation of livestock and other BMPs were met or exceeded, and all educational goals were met. Project deliverables included the development of off-creek water for livestock. In Phase II, we developed 6 new springs and rehabilitated 3 more, and ran 12 miles of pipeline to 19 new livestock tanks. Phase II water developments influence an estimated 2,414 acres in the project area. Over 4.5 miles of new fencing protects 75 acres of riparian areas, springs and/or aspen stands inside 10 exclosures. These exclosures function to either protect spring sources of livestock water or facilitate revegetation of riparian areas. The combined influence of off-creek water developments and exclosures has resulted in an estimated removal of over 82 tons/yr of sediment over the project area. In addition, these BMPs have contributed to an estimated removal of 777 lbs/yr of nitrogen and 118 lbs/yr of phosphorus. Over 350 acres of conifers encroaching in riparian areas and aspen stands were removed, and at least 3,800 willow pole cuttings were planted in riparian areas.

Water quality monitoring and BMP modeling revealed significantly reduced bank erosion on project area streams where BMPs were implemented. For the four-year period of 2010-2013, we estimate that sediment loading in the portion of Grass Creek influenced by BMPs implemented during Phases I and II has been reduced by an estimated 1,260 tons/yr. Over the same four-year period, sediment loading on Left Hand Creek, where BMPs were implemented only in Phase II, was reduced by an estimated 201 tons/year.

Over the course of the project we have observed significant improvements in stream bank stability, revegetation, and biological condition in upper Grass Creek, in close proximity to sites where BMPs were implemented starting in Phase I. We have not yet measured correspondingly large improvements in Left Hand Creek, where Phase II BMPs were focused. Extreme weather events may be partly to blame. We anticipate measuring greater improvements in Left Hand and other project area streams, in Phase III.

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2.0 Background

Over the past decade, landowners throughout the Cottonwood and Grass Creek watersheds have made significant strides to protect the resources within their watersheds. In 2004, the landowners formed the Cottonwood Creek/Grass Creek Coordinated Resource Management group (CRM), which sought to address invasive species control. In 2006 the group received a $300,000 grant to conduct a Level I Watershed Management Plan study, which was completed in 2007. The study revealed both watersheds as having been significantly grazed by domestic livestock in the late 1800s, significantly degrading the rangeland. In 2007, the CRM became formally organized as the Cottonwood/Grass Creek Watershed Improvement District (WID). In 2010, the WID completed a Level II watershed study to assess water storage challenges and opportunities in the region.

The Level I study concluded that the Cottonwood and Grass Creek watersheds were heavily grazed by domestic livestock (both cattle and sheep) in the late 1800s, and that the rangeland suffered significant degradation and damage during that time. Though some areas within the watersheds have substantially recovered, many remain significantly damaged and degraded. While changes in range management have yielded improved ecological range conditions ranging from "high fair" to "good," riparian zones continue to be damaged by wildlife and livestock relying on these areas for water, feed values, and cover. Riparian zones within the watersheds continue to exhibit geomorphic stream instability and high rates of in-stream sedimentation, with the Level I report noting that:

> The single most important factor needed to facilitate improved grazing management and thereby achieve the associated benefits to the watershed is well-distributed, reliable livestock water. In addition to restoration of more healthy conditions in currently impacted riparian areas, continuing improvements in overall range management will contribute to the maintenance, recovery or improvement of a variety of interrelated aspects of watershed function, including but not necessarily limited to:
>
> - Improved infiltration of snowmelt and rainfall;
> - Retention of soil moisture;
> - Groundwater recharge;
> - Sustained release of soil moisture and groundwater as seeps/springs; and
> - Stabilization of soils against erosion into streams.

WDEQ classifies the entire length of Grass Creek as a Class 2AB stream, with designated uses for "drinking water supplies, non-game fisheries, cold-water fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic values" (WDEQ 2010). WDEQ has four existing monitoring stations on Grass Creek (WB36, WB37, WB38, and WB186); these stations were sampled in 1998, 2003 and/or 2005.

When last monitored, the upstream stations on Grass Creek (WB37 and WB38) appeared to be in better condition than the lower stations, but the upper reaches of Grass Creek are not without problems, only ranking "fair" biologically. In 2005, WDEQ reported that the creek generally suffered from unstable banks and down-cutting: "The unstable banks appear to be due to lateral

movement of the channel in response to historic land uses…in 2003, a lower than expected habitat score was attributed to pool substrate comprised of fine particles (sand, mud, clay), elevated sediment deposition, marginal channel sinuosity, and a narrow riparian zone width." The reach above the first major irrigation canal in NENE of Sec. 23, T46N, R99W, just upstream of the oil field, was supporting aquatic life uses (Category 2). The downstream stations, near the Grass Creek oil field and Highway 120, were in poor to very poor condition biologically (WY DEQ 2005). Downstream of the irrigation diversion, aquatic life uses were not supported due to flow alterations (Category 4C) (WDEQ 2003; 2005).

Primary land uses in the Grass Creek watershed are livestock grazing and mineral development, with irrigated agriculture being a secondary land use. Historic land uses have resulted in lateral movement of the stream channels, and steeply eroded streambanks in some reaches. In the stream segments within the project area, sediment is the primary nonpoint source pollutant of concern (WDEQ 2005).

Enos Creek and Left Hand Creeks are streams within the Gooseberry Creek-Enos Creek HUC. WDEQ has not made designated use support determinations for either Enos or Left Hand Creeks, but did collect data from a statewide probability site on Enos Creek (43.96845556, -108.76299720) in 2008. BLM reports on Enos Creek (2000, 2004) indicate that fires in the watershed in 2000 were causing excessive run-off and riparian-wetland degradation and that the system was vertically unstable. Natural surface or subsurface flow patterns were altered by hoof action disturbance. In 2006, the BLM classified Left Hand Creek as "functioning at risk" with a downward trend due to degradation attributed to livestock.

Cottonwood Creek receives discharge water from the Hamilton Dome Oil Field, resulting in high concentrations of both chloride and selenium. Because the discharge water is used for irrigation and the oil field is an important part of the local economy, a Use Attainability Analysis (UAA) was conducted and approved on Cottonwood Creek. WDEQ classifies the main stem of Cottonwood Creek as Class 2AB surface water, which supports cold water fish, aquatic life, and wildlife uses. As a Category 2 body of water on the WDEQ's 305(b) list, available data and information for Cottonwood Creek indicate that at least one designated use is supported, while one or more other uses are either indeterminate or not assessed. The CRM worked for years to rid Cottonwood Creek drainage of Russian olive and tamarisk (salt cedar) which had heavily infested this body of water.

The major objective of the Grass Creek Stewardship Project is to improve overall stream health by reducing livestock activity in riparian areas. Primarily, this is accomplished through the development and implementation of BMPs enabling livestock to graze in areas of rangeland away from riparian zones. Phase II of this project was a continuation of the Phase I initiative launched on the LU Ranch following a request by its owner for assistance from The Nature Conservancy in establishing a comprehensive range monitoring program for the ranch. During Phase I, we collected baseline data and implemented a small number of BMPs on the 150,000-acre LU Ranch. We implemented all Phase I BMPs on Grass Creek. Phase I also included the development of the Phase I Grass, Enos, and Left Hand Creek Non-Point Source Reduction Project Sampling and Analysis Plan (2010), to be implemented during subsequent project phases. The secondary objective of this project is to assess the suitability of project area streams as

restoration sites for Yellowstone Cutthroat Trout. As this is a long-term restoration project, and complete results of this project will not be immediate, a comprehensive assessment of this objective will not be possible for several years.

Our Phase II work expanded the area of BMP implementation and prepared us to further expand these efforts during Phase III. The primary emphasis of this phase was to implement a significant number of BMPs in the project area. In Phase II, the area of BMP implementation focused on Little Grass and Left Hand Creeks but extended into the Cottonwood Creek drainage. We constructed 4 riparian exclosures on both Little Grass and Grass Creeks, inside of which we planted 3,800 willow pole cuttings. In the Little Grass Creek drainage, we also removed 43 acres of conifers encroaching into the riparian area, protected an aspen stand and developed a spring and then protected it with a fence. In the Left Hand Creek drainage, we controlled hundreds of acres of encroaching conifers and controlled weeds on ~64 acres. We also developed four off-creek water systems (two of them solar-powered with 5,000 gallon storage tanks) on Left Hand Creek. These included 14 livestock water tanks, 1 re-plumbed water tank, 3 spring developments, 1 rehabilitated artesian well, 2 storage tanks, and almost 10 miles of pipeline. These water developments, along with the Phase I developments and others completed independently of the 319 projects, now provide off-creek water to the vast majority of the LU Ranch, enabling the ranch to keep their cows off streams across almost 150,000 deeded and leased acres. Three springs developed in Phase II on Left Hand Creek were protected with fences. In the Cottonwood Creek drainage, we developed three additional springs.

In Phase II, we also collected baseline range monitoring data on the 56,000-acre Hillberry ranches (three adjacent ranches owned by Dee Hillberry: Prospect Land and Cattle Co., Spring Gulch Cattle Company, and HD Quarter Circle). This was done in addition to continuing range monitoring on the LU Ranch.

Following protocol established under our approved Sampling and Analysis Plan (2010), we also monitored water quality and changes in riparian vegetation communities between 2012 and 2015 on the four creeks in the Phase I project area (project no. ON804).

A project amendment and two extensions for Phase II work were granted in 2013 and 2014, providing additional time and funding for the completion of willow plantings, conifer control, weed treatments, and the construction of three spring protection fences. This work was completed by the end of 2015 and is included in this report.

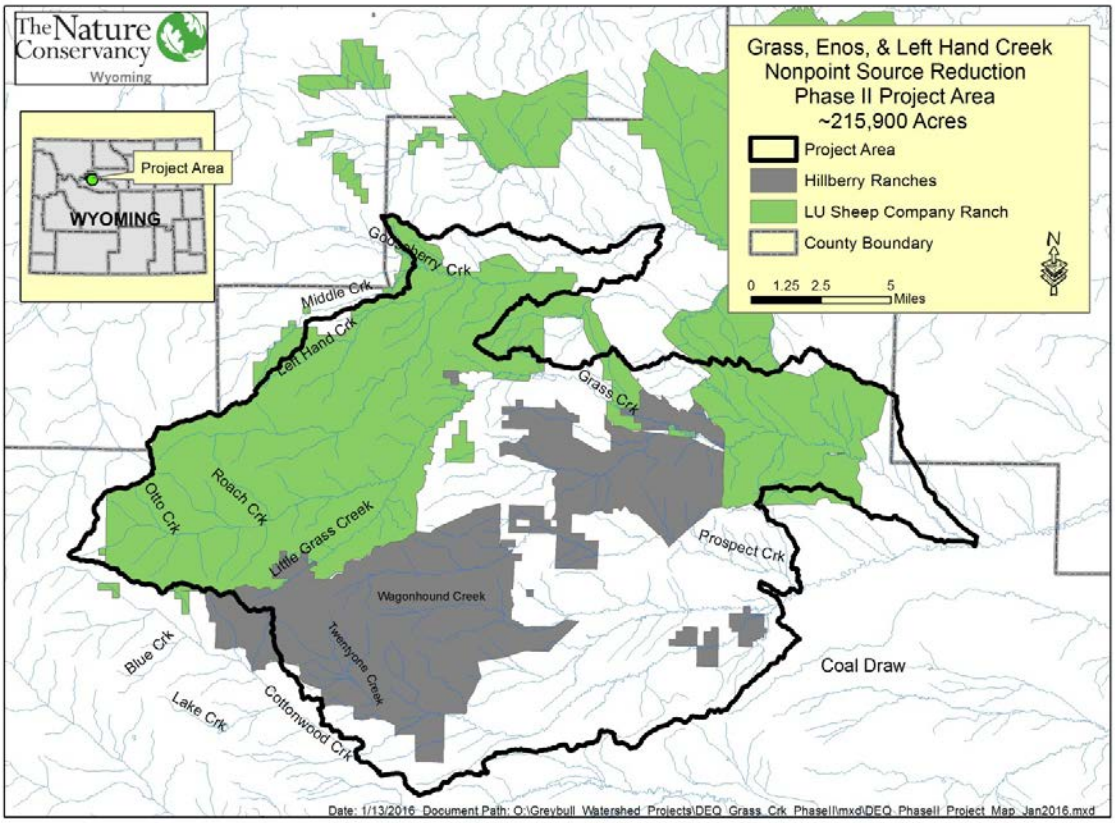


Figure 1. The Phase II project area showing the extent of the LU and Hillberry Ranches.

The project area covers over 215,000 acres and encompasses the drainages of two major tributaries of the Bighorn River: Gooseberry Creek and Cottonwood Creek (Figure 1). Phase I of this project commenced in 2008 on Grass, Little Grass, Enos, and Left Hand Creeks. The entire lengths of Grass Creek and Enos Creek are classified as Class 2AB waters whereas Little Grass and Left Hand Creeks are classified as Class 3B waters. Designated uses assigned to Class 2AB waters are coldwater fisheries, non-game fisheries, drinking water, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture and scenic value (WDEQ/WQD 2013). Designated uses assigned to Class 3B waters are similar to Class 2AB less drinking water, fish consumption, coldwater fisheries and non-game fisheries (WDEQ/WQD 2013). In Phase II (begun in 2012), implementation of Best Management Practices (BMPs) for water quality improvement expanded from Grass Creek to Left Hand and Little Grass Creeks. Range monitoring was also expanded to the Hillberry Ranches.

The Nature Conservancy has served as the lead on this project, providing project management and oversight, securing and managing funding, and involving numerous project partners in project planning and implementation. Representatives of the LU and Hillberry Ranches, the Natural Resource Conservation Service (NRCS), the Bureau of Land Management (BLM), the Wyoming Department of Agriculture, the University of Wyoming Cooperative Extension, the University of Wyoming Conservation Corps (WCC), Wyoming State Forestry, the Wyoming

Game and Fish Department (WGFD), Hot Springs Weed and Pest District, the Cottonwood / Grass Creek Coordinated Resource Management Group, and the Hot Springs Conservation District have worked with The Nature Conservancy to develop and accomplish project goals. In addition to the Wyoming Department of Environmental Quality (WDEQ), funding was provided by the Wyoming Sage-Grouse Conservation Fund, the Wyoming Wildlife and Natural Resource Trust Fund, Marathon Oil, and the LU Ranch. Many of the aforementioned partners also provided technical assistance, in-kind labor, equipment, and materials.

3.0 Goals and Outcomes

The primary goal of the project is to improve overall stream health by reducing livestock activity in riparian areas. We are assessing this improvement throughout the project area using a number of water quality and range monitoring methods to measure or model sediment inputs and mean stream temperatures. We are also seeking to maintain or improve riparian and aquatic habitat through improved livestock distribution, monitoring, and adaptive management. The secondary objective of this project is to assess the suitability of project area streams as restoration sites for Yellowstone cutthroat trout. As this is a long-term restoration project, and complete results of this project will not be immediate, a comprehensive assessment of these streams as restoration sites will not be possible for several years. We are primarily accomplishing these broad project goals through the development and implementation of BMPs encouraging livestock to graze in areas of rangeland outside of riparian zones.

Our specific goals for Phase II of this project are broken down by Grass and Little Grass Creeks, Enos and Left Hand Creeks, and Cottonwood Creek. On Grass and Little Grass Creeks, our goals were to: 1) reduce sediment inputs through installation of riparian fencing and the replacement of non-desirable plants in riparian areas with native, woody species, 2) to encourage beaver migration into the upper elevations of these drainages by maintaining existing aspen stands and reestablishing willow and cottonwood-dominated riparian areas, and 3) to expand range and water quality monitoring begun in Phase I. We successfully met goal 1) within the project period, installing 2 riparian fences on Grass Creek and 2 riparian fences and 1 aspen fence on Little Grass Creek, for a total of 5 fences. These 5 fences will reduce sediment loading from the watershed at an estimated rate of 5.42 tons/yr, as calculated using the Spreadsheet Tool for Estimating Pollutant Loads (StepL). Results of aspen monitoring reveal that we also satisfied goal 2) for the Phase II project period. Counts of aspen within stands remained stable from 2011 to 2012. As we only have two years of data, it is not yet possible to conclude whether or not aspen stands have improved within the project area. Goal 3) for Grass and Little Grass Creeks was satisfied in part, however we modified our plans for range and water quality monitoring expansion due to findings that too many streams in our project area are ephemeral.

On Enos and Left Hand Creeks, our Phase II goals were to: 1) develop 12 new off-creek water sources on Left Hand Creek and to herd cattle from riparian areas to these new tanks, 2) treat juniper and other conifer species encroaching into riparian stands on both creeks, so as to complement recent NRCS conifer control on Enos Creek (Figure 2), and 3) to expand range and water quality monitoring begun in Phase I. During Phase II, we installed or rehabilitated 19 livestock water tanks across the project area, surpassing our goal to install 12 tanks. Using StepL, we calculate that these water developments have led to a reduction in sediment loading of at least 28.26 tons/yr. We exceeded our conifer control goal, removing over 350 acres of conifers as

compared with our target of 275 acres, only we decided to focus on the Left Hand Creek drainage instead of Enos Creek because the issues there were more acute and we were already investing in that drainage through livestock water development. Additionally, we performed 43 acres of conifer control on Little Grass Creek. In Phase III, we will focus on conifer control on the Hillberry Ranches. Finally, while we expanded range monitoring onto the Hillberry Ranches in Phase II, we did not significantly expand our water quality monitoring program there. As discussed in greater detail below, the ephemeral nature of many of the streams in the southern portion of the project area convinced us that added effort on our part was likely to result in diminishing returns. We focused, instead, on implementing additional BMPs in that portion of the project area.

Figure 2. Enos Creek before and after NRCS removal of conifers encroaching into the riparian area.

Finally, our Phase II goals for Cottonwood Creek were to: 1) initiate range monitoring on the 56,000 acre (deeded and leased) Hillberry Ranches in anticipation of implementing BMPs in this drainage in the future. During Phase II of this project, we assisted with the development of a comprehensive range monitoring program on the Hillberry Ranches, described herein.

PROJECT PRODUCT SUMMARY

Product Outcome: The primary outcome for this project was to reduce sediment loading and mean temperature in stream channels, and to maintain or improve riparian and aquatic habitat through improved livestock distribution, monitoring and adaptive management at selected sites.

Target 1: Efficient Project Administration.

Target 2: Grazing Management and BMP Implementation to improve surface water designated uses.

Target 3: Control non-desirable plant species in the Grass, Little Grass, Enos and Left Hand drainages.

Target 4: Expand voluntary range monitoring by landowners within project area; continue water quality monitoring sites established in Phase I.

Target 5: Plant pole cuttings of native tree species in riparian areas on Grass/Little Grass Creeks.

4.0 Task Activities

This project helped to implement the Wyoming Nonpoint Source Management Plan in several ways, including through the:

- implementation of BMPs to reduce erosion,
- improvement of riparian habitat through native vegetation plantings and livestock exclusion,
- removal of non-desirable species from riparian areas,
- continuation of appropriate livestock grazing across the project area,
- continuation of comprehensive range and water quality monitoring programs, and
- demonstration of range and water quality monitoring techniques.

Planned and actual milestones for tasks are presented in Table 2. These are based on the amended grant agreement that allowed a two-year extension on the grant through 2015.

Table 2: Task Descriptions and Project Deliverables.

Task #	Task Title	Task Description	Actual Deliverables
1	Project Administration	1 Final Report, 8 Quarterly Reports	1 Final Report, 2 Annual Reports, 10 Quarterly Reports
2	Implementation of Grazing Management BMPs	Off-creek water tanks, spring protection fences, storage tanks, solar pumps, livestock herded to new tanks	19 off-creek water developments with an effective influence on 2,414 acres that consist of 9 spring developments, 19 livestock tanks, over 12 miles of pipeline, 2 solar-powered pumping systems, 2 5,000-gallon water storage tanks and the herding of livestock to new tanks. Over 3/4 of a mile of fence protects 7.5 total acres surrounding 4 springs - 3 on Left Hand and 1 on Little Grass Creek.
3	Control of Non-Desirable Plants	275 treated acres of conifers, spray new weed infestations	About 350 treated acres of conifers, ~64 acres of weed control (musk thistle, Canada thistle)
4	Monitoring and Outreach	Range and water quality monitoring programs established, outreach conducted	LU and Hillberry Ranches range and water quality monitoring programs established. Project outreach conducted under a separate WDEQ-funded project. Sediment from bank erosion in BMP-influenced portions of project area streams was reduced by 1,260 tons/yr in Grass Creek and 201 tons/yr in Left Hand Creek. Reductions in the Little Grass Creek drainage will be presented in the Phase III report. Monitoring results and trends are discussed in Section 6.0 Monitoring Results.
5	Revegetation of Grass and Little Grass Creek	Riparian fences, 2,000 native tree plantings	Almost 4 miles of fence in six units protect over 75 acres, including: 2 riparian fences on Little Grass Creek, 2 riparian fences on Grass Creek, 1 riparian fence on Prospect Creek, 1 aspen protection fence on Little Grass Creek. Approximately 3,800 willows planted.

Task 1: Administration

The Nature Conservancy's Northwest Wyoming Program Director and Grants Specialist worked together to administer this grant project, including timely submission of reports and reimbursement requests, records retention, and completion of all tasks.

Task 2: Best Management Practice Implementation

In 2012, the Conservancy began work with the LU Ranch and a contractor to construct off-creek water sources for livestock and wildlife to improve riparian area health and water quality. Exceeding our original task goal of twelve, nineteen water tanks were installed and fed from 6 new spring developments and 3 rehabilitated developments through over 12 miles of pipeline (also exceeding our goal to install 5 miles of pipeline). The majority of these systems are gravity fed but two spring developments utilize solar panel systems that pump water to above ground water storage tanks which then gravity feed to the livestock tanks. Though we planned to develop 12 springs in our original Phase II PIP, we found that a few springs did not have enough water to warrant development. Further, we found it to be more cost effective to focus our resources on piping water from higher capacity springs over a greater distance. With this approach, we distributed much more water than planned. Additionally, four fences were constructed around springs developed in Phase II in order to protect the development and riparian area alike.

Task 3: Control of non-desirable plant species

The Conservancy worked with three different contractors, a Wyoming Conservation Corps crew, and the BLM to clear around 90 acres of junipers and other undesirable conifers from Left Hand Creek, 215 acres from Middle Creek (in the Left Hand drainage), and 43 acres from riparian areas and aspen stands on Little Grass Creek for a total of 356 acres, exceeding our target of 275 acres. Additionally, a contractor was hired in 2015 to spray Canada and musk thistle on ~64 acres of riparian area on Left Hand Creek.

Task 4: Monitoring and Outreach

TNC analyzed changes in water quality associated with the project; data collected may be used by landowners and agencies to support management decisions, and was a continuation of the information collected in Phase I of the project.

Range Monitoring

In Phase II, data were collected on both the LU and Hillberry Ranches. The LU Ranch continued to collect data in accordance with their monitoring plan established during Phase I of the project. The data collected helped the ranch to identify areas that were being under or over utilized to ensure proper grazing rotation and grass utilization. The Hillberry Ranches are likewise using their data to help make informed management decisions and to supplement the range monitoring data collected by the BLM on the ranch's public land leases.

In Phases I and II we established comprehensive range monitoring across a large portion of our project area. However, the project did not include enough funding for a thorough analysis of the

range monitoring results. And further, not enough time has yet elapsed for the ranches to have made (and measured) improvements to their range management practices. We hope to analyze the range monitoring results during Phase III, and will report our findings and possible links between conditions and implemented BMPs in our Phase III final report.

Water Quality Monitoring

Phase II of the project continued to track changes in riparian vegetation, sediment, and water temperature at the nine previously established sites on Grass, Little Grass, Enos, and Left Hand Creeks. As described more fully in Section 6.0, over the course of the project the implementation of grazing BMPs reduced the impacts of cattle to riparian areas. Bare ground and noxious weeds decreased at several of our monitoring sites. The diversity and the proportion of sensitive taxa in the macroinvertebrate communities increased throughout the project area as measured by multiple indices. Sediment loading was reduced by 1,497 tons/year throughout the project area, while nitrogen inputs were reduced by 777 lbs/year and phosphorus was reduced by 118 lbs per year.

No new monitoring sites were added on Left Hand Creek because the majority of the stream is spring fed for short distances and then becomes ephemeral. Likewise, new water quality monitoring sites were not established on the Hillberry Ranches because many streams on the ranch were discovered to be ephemeral.

Outreach

In Phase I, the range monitoring program only existed on the LU Ranch; TNC met its outreach goal by hosting a range monitoring workshop for area landowners. In Phase II, we expanded the range monitoring program to the adjacent Hillberry Ranches. The Hillberry Ranches hired local range consultants to help establish monitoring sites, collect the range monitoring data, and to teach the methods to (and share the data with) the ranch's lessees so they can better judge utilization levels and grazing rotations. We also shared information about this project, and about range and water quality monitoring, at the 2013, 2014, and 2015 Cody Wild West River Fest events held in Cody, Wyoming.

Task 5: Revegetation of Grass and Little Grass Creek drainages

Native Tree Plantings

Around 3,800 native willow poles were cut from dense populations on the LU Ranch and out planted in the Grass and Little Grass Creek drainages in the spring of 2013 and 2014. This greatly exceeded our PIP target of 3,000 plantings. In 2013, a crew of Wyoming Honor Farm workers helped plant the first 700 poles on Grass Creek and in 2014 a contractor helped TNC staff cut and plant the other 3,100 poles on both Grass and Little Grass Creeks. The poles were planted in groups or bundles inside riparian fences spanning roughly 2.25 miles of streamside riparian area. Although we have not quantified the survival rates of these plantings, periodic visual follow-up monitoring has shown excellent survival rates of the cuttings.

Riparian/Aspen Fences

Riparian and aspen protection fences were built in order to exclude cattle from certain sections of the streams to allow vegetation, specifically cottonwood, willows and aspen, to regenerate in the absence of grazing pressure. Five riparian fences were built; two on Little Grass Creek, two on Grass Creek, and one on Prospect Creek. The Little Grass Creek fences enclose about 30 acres and 1.1 mile of stream; one of the fences adjoined two existing fence corners thereby increasing the acreage enclosed for relatively minimal cost. The Grass Creek fences enclose 7.3 acres of riparian area and a half-mile of stream. The Prospect Canyon fence encloses about a half mile of stream, 15 acres of aspen, and a spring. A sixth fence on upper Little Grass Creek protects a 15-acre aspen stand. In total, we built close to 4 miles of fence under this task, exceeding our goal of building 3 miles of fence in Phase II.

5.0 BMP Implementation: Implementation of Water Quality Improvement Practices

In Phase II of this project, we developed 19 off-creek livestock tanks and we built 10 exclosures to protect riparian areas, springs and aspen stands from livestock (Table 3). Of these tanks and exclosures, all but Tank #16, Tank #17, Tank #18, Tank #19, and Exclosure #5 fell were in hydrologic unit 100800070607. All remaining BMPs were in hydrologic unit 100800070609. Descriptions of each BMP are listed in Table 3.

Off Creek Water Developments: LU Ranch

Fifteen (15) of the water tanks installed in Phase II were built in the Left Hand Creek drainage on the LU Ranch (Figure 3). All the new water tanks were equipped with wildlife escape ramps and float valves that enable excess water to overflow back into riparian areas. Prior to this project, the two Left Hand pastures (totaling about 10,000 acres) contained only two water tanks and a small reservoir – cattle mostly watered directly on riparian areas. Many of the stream segments in the Left Hand drainage are ephemeral and do not provide year round water.

The first LU Ranch water development, State West Spring, is located at the head of the right fork of Left Hand Creek. This system had been developed many years ago to feed a small pond at the site. In 2012 TNC hired a contractor to install a proper collection area so the water could be gravity fed away from the riparian area and pond to two new water tanks (Figure 3, Tanks #1-2). The second water development, State North Spring, gravity flows to three new water tanks (Figure 3, Tanks #3-5). The third new water system on Left Hand is the WCC Spring. This spring development gravity flows to three new livestock tanks (Figure 3, Tanks #6-8) located on LU Ranch deeded ground. The fourth development, Lek Spring, uses solar pumping and a large storage tank to fill four new livestock tanks (Figure 3, Tanks #9-12). During the day, the solar pump fills a large storage tank installed on a ridge above the livestock tanks. Then the stored water gradually gravity feeds to the four tanks, providing water for the roughly 3,000-acre lower Left Hand pasture that previously had no off-creek water. The fifth development on Left Hand Creek, Solar Well, fitted a solar pump to a well that had previously just functioned as an artesian well that gravity fed to Tank #15 (Figure 3). The addition of the solar pump allowed for the expansion of the existing system with two new water tanks (Figure 3, Tanks #13-14).

Table 3. Summary of BMPs Implemented and Pollutant Reductions Estimated in Phase II. Sediment, Nitrogen, and Phosphorus reductions were estimated using StepL.

	BMPs Implemented			Pollutant Reduction Estimates		
	Phase Completed	Date Constructed / Years Measured	Estimated Acres / Miles Affected	Sediment (tons/yr)	N (lbs/yr)	P (lbs/yr)
Grass Creek						
Off-Creek Water Developments			Acres			
Tanks #1 and #2 Otto/Sanford	Phase I	Aug-10	52.90	-5.10	-5.00	-1.80
Tanks #3 and #4 Hess	Phase I	Aug-10	25.06	-4.20	-4.00	-1.50
Tank #5 Thompson	Phase I	Aug-10	12.80	-4.50	-4.00	-1.60
Exclosures			Acres			
Excl #1 Otto/Sanford	Phase I	Jun-11	3.40	-1.90	-5.00	-1.30
Excl #2 Otto/Sanford	Phase I	Jun-11	2.30	-1.30	-4.00	-1.00
Excl #3 Hess	Phase I	Jun-11	0.70	-0.40	-1.00	-0.30
Excl #4 Thompson	Phase I	Jun-11	0.50	-0.30	-2.00	-0.40
Excl #3 Upper Riparian	Phase II	Apr-13	3.40	-0.42	-2.20	-0.60
Excl #4 Lower Riparian	Phase II	Apr-13	3.90	-0.47	-2.60	-0.60
Mean Stream Bank Erosion Reduction in Segments influenced by BMPs (tons/yr)			Miles			
GC Type 1	Phases I & II	2010 - 2013	7.70	-1,070.40	-	-
GC Type 2	Phases I & II	2010 - 2013	2.40	-171.40	-	-
Grass Creek Pollutant Reduction Subtotals				-1,260.39	-29.80	-9.10
Little Grass Creek						
Off-Creek Water Developments			Acres	Sediment (tons/yr)	N (lbs/yr)	P (lbs/yr)
Tank #16 Elk Mntn	Phase II	Aug-13	618.00	-10.40	-227.40	-27.30
Exclosures			Acres			

Excl #1 Upper Riparian	Phase II	Nov-12	27.00	-2.57	-1.60	-3.80
Excl #2 Lower Riparian	Phase II	Nov-12	3.40	-0.42	-2.20	-0.60
Excl #6 Aspen	Phase II	Oct-14	15.00	-1.54	-9.00	-2.20
Excl #10 Elk Mnt Spring Protect	Phase II	Aug-15	5.30	-0.30	-3.20	-0.50
Mean Stream Bank Erosion Reduction in Segments influenced by BMPs (tons/yr)						
LG Type 1	Phases I & II	2010 - 2013	To be assessed in Phase III			
LG Type 2	Phases I & II	2010 - 2013	To be assessed in Phase III			
LG Type 3	Phases I & II	2010 - 2013	To be assessed in Phase III			
Little Grass Pollutant Reduction Subtotals				-15.23	-243.40	-34.40
Left Hand Creek						
Off-Creek Water Developments			Acres	Sediment (tons/yr)	N (lbs/yr)	P (lbs/yr)
Tank #1 State West	Phase II	Jun-13	8.60	-1.23	-2.20	-0.80
Tank #2 State West	Phase II	Jun-13	6.10	-1.22	-2.20	-0.80
Tank #3 State North	Phase II	Sep-13	55.00	-1.00	-1.80	-0.80
Tank #4 State North	Phase II	Sep-13	61.00	-0.65	-1.20	-0.40
Tank #5 State North	Phase II	Sep-13	78.70	-0.86	-1.60	-0.60
Tank #6 WCC	Phase II	May-13	91.50	-1.05	-2.00	-0.80
Tank #7 WCC	Phase II	May-13	12.50	-0.69	-1.20	-0.40
Tank #8 WCC	Phase II	May-13	25.10	-0.46	-0.80	-0.40
Tank #9 Lek	Phase II	Aug-13	22.60	-3.99	-7.20	-2.80
Tank #10 Lek	Phase II	Aug-13	49.50	-3.26	-6.00	-2.40
Tank #11 Lek	Phase II	Aug-13	13.40	-4.57	-8.20	-3.20
Tank #12 Lek	Phase II	Aug-13	47.70	-6.71	-12.40	-4.80
Tank #13 Solar	Phase II	Oct-13	78.60	-0.71	-1.40	-0.60
Tank #14 Solar	Phase II	Oct-13	36.00	-1.08	-2.00	-0.80
Tank #15 Solar	Phase II	Oct-13	4.70	-0.78	-1.40	-0.60

Exclosures			Acres			
Excl #7 State N	Phase II	Nov-15	0.50	-0.10	-0.60	-0.10
Excl #8 Lek spring	Phase II	Nov-15	0.50	-0.10	-0.60	-0.10
Excl #9 WCC Spring	Phase II	Nov-15	1.20	-0.10	-0.80	-0.10
Mean Stream Bank Erosion Reduction in Segments influenced by BMPs (tons/yr)			Miles			
LH Type 1	Phase I & II	2010 - 2013	1.70	-9.90		
LH Type 2	Phase I & II	2010 - 2013	1.20	-1.20		
LH Type 3	Phase I & II	2010 - 2013	9.20	-161.10		
Left Hand Pollutant Reduction Subtotals				-200.76	-53.60	-20.50
Wagonhound Creek (trib to Cottonwood Ck)						
Off-Creek Water Developments			Acres	Sediment (tons/yr)	N (lbs/yr)	P (lbs/yr)
Tank #17 Wagonhound	Phase II	Nov-13	1,120.00	-16.70	-405.50	-47.00
Tank #18 Ojinaga	Phase II	Nov-13	39.00	-1.30	-16.50	-2.60
Tank #19 West Dugout	Phase II	Nov-13	46.00	-1.50	-19.40	-3.00
Exclosures			Acres			
Excl #5 Prospect Riparian/Aspen	Phase II	Aug-12	15.00	-0.80	-8.70	-1.40
Wagonhound Pollutant Reduction Subtotals				-20.30	-450.10	-54.00
				Sediment (tons/yr)	N (lbs/yr)	P (lbs/yr)
Pollutant Reduction Totals in Phases I and II				-1,496.68	-776.90	-118.00
Acres Directly Impacted by BMPs						
Water Developments	Phases I & II	2,504.76	Phase I:	90.76	Phase II:	2,414.00
Exclosures	Phases I & II	82.10	Phase I:	6.90	Phase II:	75.20

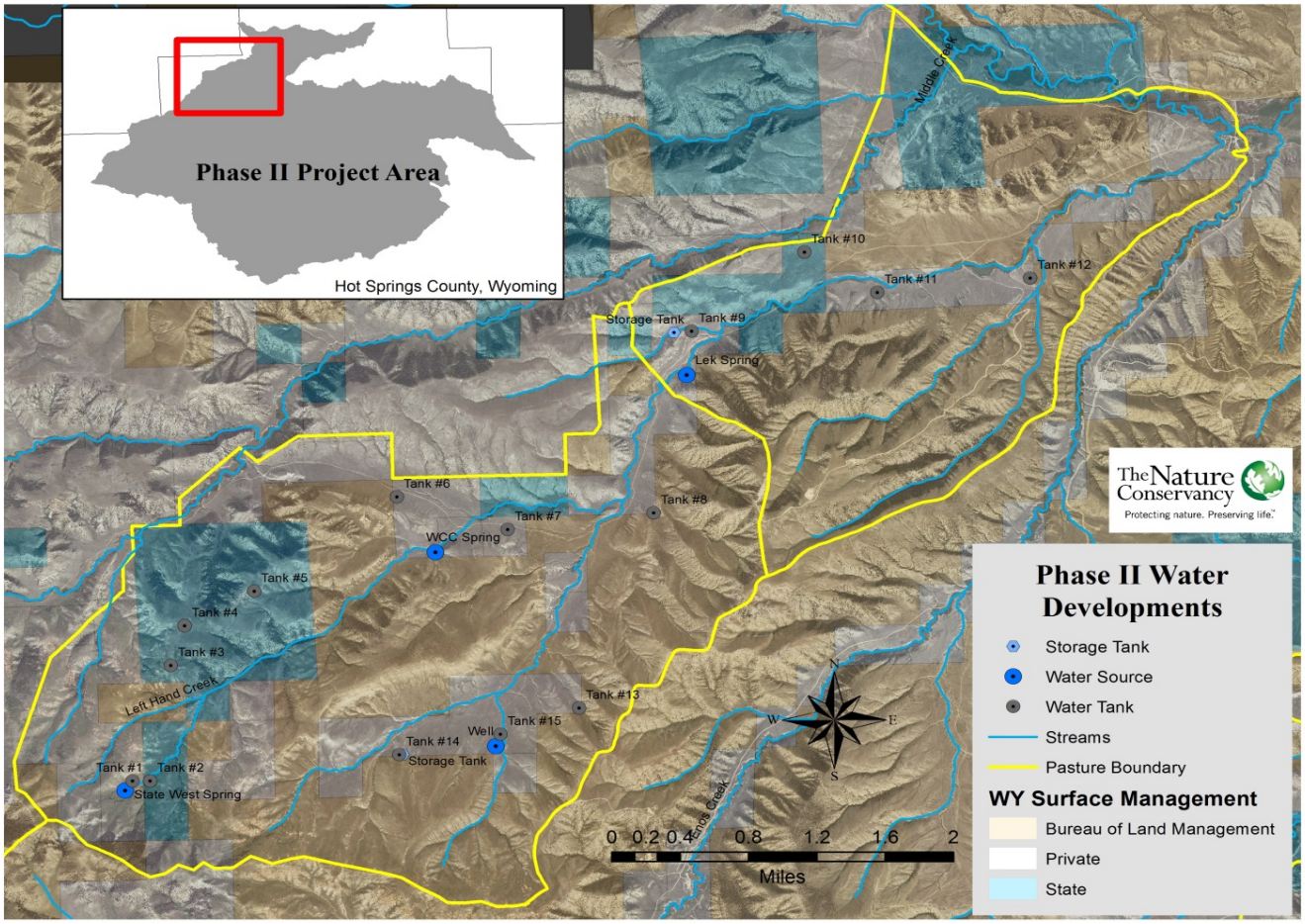


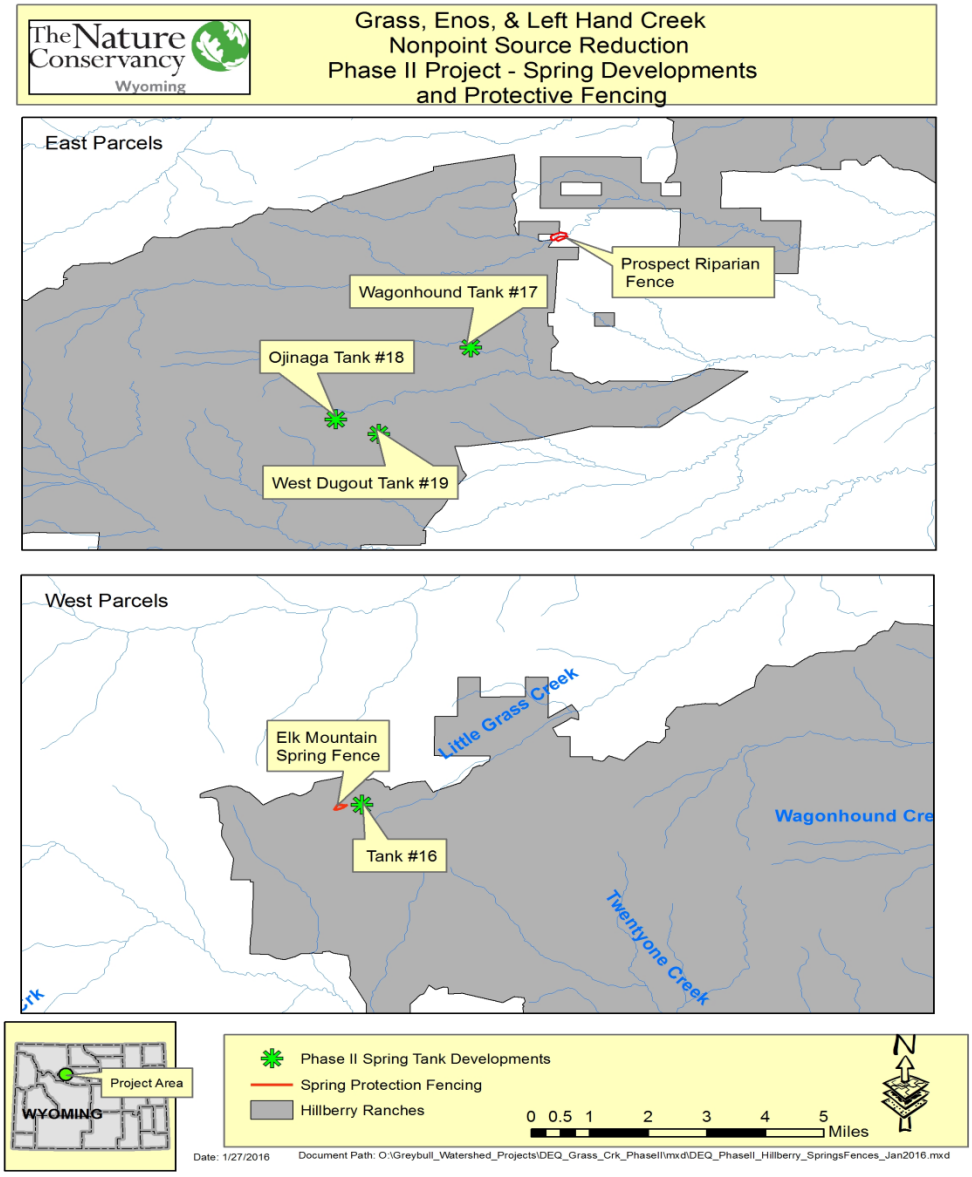
Figure 3. Phase II water developments in the Left Hand Creek drainage on the LU Ranch.

Off Creek Water Developments: Hillberry Ranches

Four water systems were installed, expanded, and/or rehabilitated on Little Grass Creek and Cottonwood Creek tributaries on the Hillberry Ranches in 2015 (Figure 4). All the new water tanks were equipped with wildlife escape ramps and float valves that enable excess water to overflow back into riparian areas.

The first Hillberry Ranches water development, Elk Mountain Spring, gravity feeds away from the Prospect Creek riparian area to one new water tank (Figure 4, Tank #16). The second development, Wagonhound, is an expansion of an existing multi-tank system in the Prospect Creek drainage. With Phase II funding, we added one new water tank (Figure 4, Tank #17) to the system. The third and fourth developments, in the Wagonhound Creek drainage, each feed to one new tank, Ojinaga (Figure 4, Tank #18) and West Dugout (Figure 4, Tank #19).

Figure 4. Water developments and exclosures completed on the Hillberry Ranches in Phase II.



Exclosure Fencing

Ten exclosures were built in the project area in Phase II to limit livestock access to a total of 75.2 acres. Table 4 provides a summary of exclosures sizes and area protected. Five of the exclosures were constructed primarily to protect riparian areas, one was built to protect an aspen stand, and four were constructed primarily to protect spring developments from trampling by livestock.

- <u>Riparian and Aspen Exclosures</u>

Five riparian exclosures and one aspen exclosure were built in Phase II. Of these six exclosures, five were built in the Grass and Little Grass Creek drainages (Figure 5). The locations of

exclosures #1-4 were selected because those areas had little to no willow growth and also offered suitable willow planting sites. Exclosure #1 was built to exclude livestock from a large portion of Little Grass Creek; only one section of fence needed to be built because the stream was already enclosed on three sides. No willows were planted in this exclosure because this portion of the creek only runs during flood periods or wet years. Exclosure #2 was built for willow outplanting and to protect existing cottonwood trees; one mature and several immature cottonwoods were present and have continued to propagate with decreased grazing pressure. It was more difficult to choose sites on Grass Creek because fortunately, regeneration of willows is now happening naturally throughout the drainage. Exclosures #3 and #4 were the most suitable sites we could find. Fence construction commenced in the fall of 2012 with the help of the Wyoming Honor Farm Crew and LU Ranch employees. The fences were completed in 2013.

One exclosure, #5, was built in 2012 to protect Prospect Creek riparian area, a spring, and an aspen stand (Figure 4). Exclosure #6 was built in 2014 in the upper Little Grass Creek drainage to enclose a 15-acre aspen stand to increase its health and regeneration rate (Figure 5).

- Spring Protection Exclosures

We also built four exclosures to protect springs developed in Phase II. State North is a small (0.5 acre) hog panel fence completed in the spring of 2015, while Lek (0.5 acres) and WCC (1.2 acres) are 3-wire, high tensile fences completed in the fall of 2015 (Figure 3). Elk Mountain Spring (5.3 acres) is also a 3-wire, high tensile fence completed in the fall of 2015 (Figure 4).

Conifer Control

Widespread fire suppression efforts in the Rockies have enabled significant expansion of shade tolerant coniferous species like juniper and Douglas fir. In the project area, these species have encroached into riparian areas, aspen stands, and spring sites where they outcompete native species for resources. In order to increase the health of these habitats, we planned to remove conifers from riparian areas and aspen stands across 275 acres of the project area in Phase II. With the help of partners, we treated over 350 acres, including 215 acres on Middle Creek (in the Left Hand Creek drainage), 90 acres on Left Hand Creek, 43 acres on Little Grass Creek, and several acres enclosed by the spring protection and riparian fences built in Phase II (Figures 5 & 6). The expectation is that this work would increase the health of these habitats by increasing the proportion of native vegetation which would contribute to improved water quality because 1) more water would stay in streams where conifers were removed from riparian areas, and 2) healthier riparian vegetation would better stabilize stream banks and better filter run-off.

Although we significantly exceeded our conifer control goal, it is difficult to prove that this work achieved our objective of water quality improvement because our water quality monitoring methods were not designed to directly measure the impacts of this work. If we had been measuring flow rates, for example, we may have recorded increased flow following conifer control. In addition, it may take some time for the benefits to be fully realized in these watersheds and follow-up monitoring in the years to come, as we suggest in the Recommendations section, may reveal the longer-term impacts of this work.

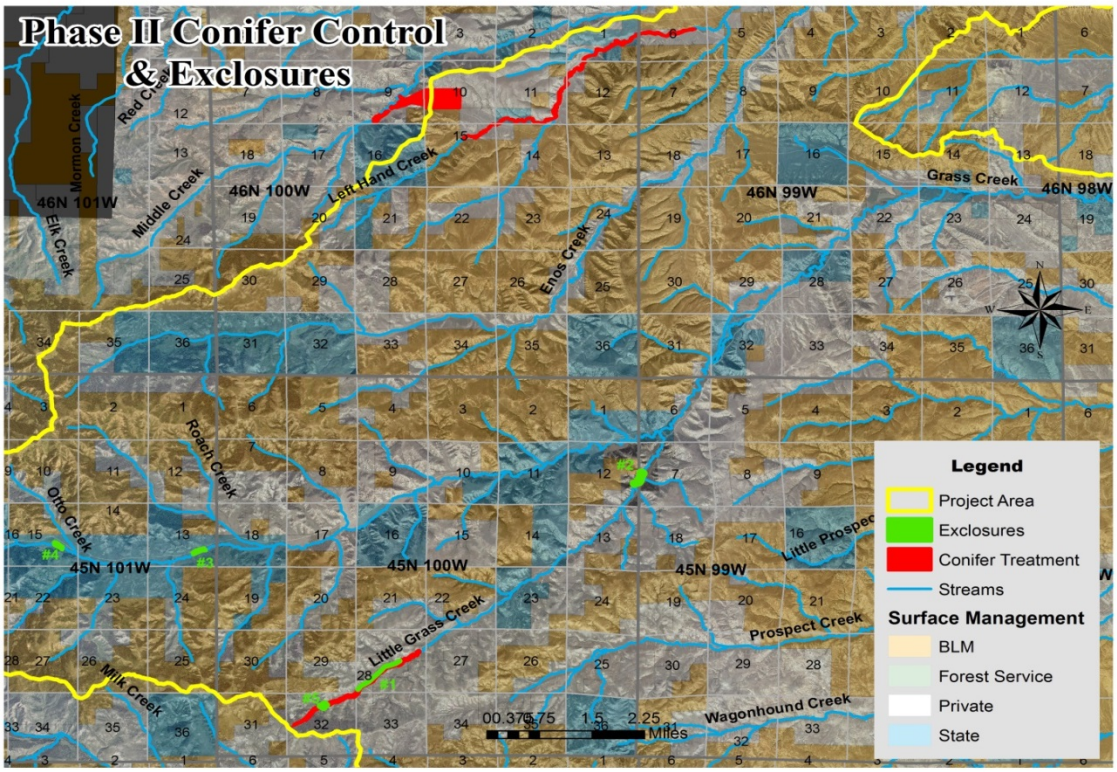


Figure 5. Exclosures and conifer control completed in the Left Hand, Grass and Little Grass Creek drainages in Phase II.

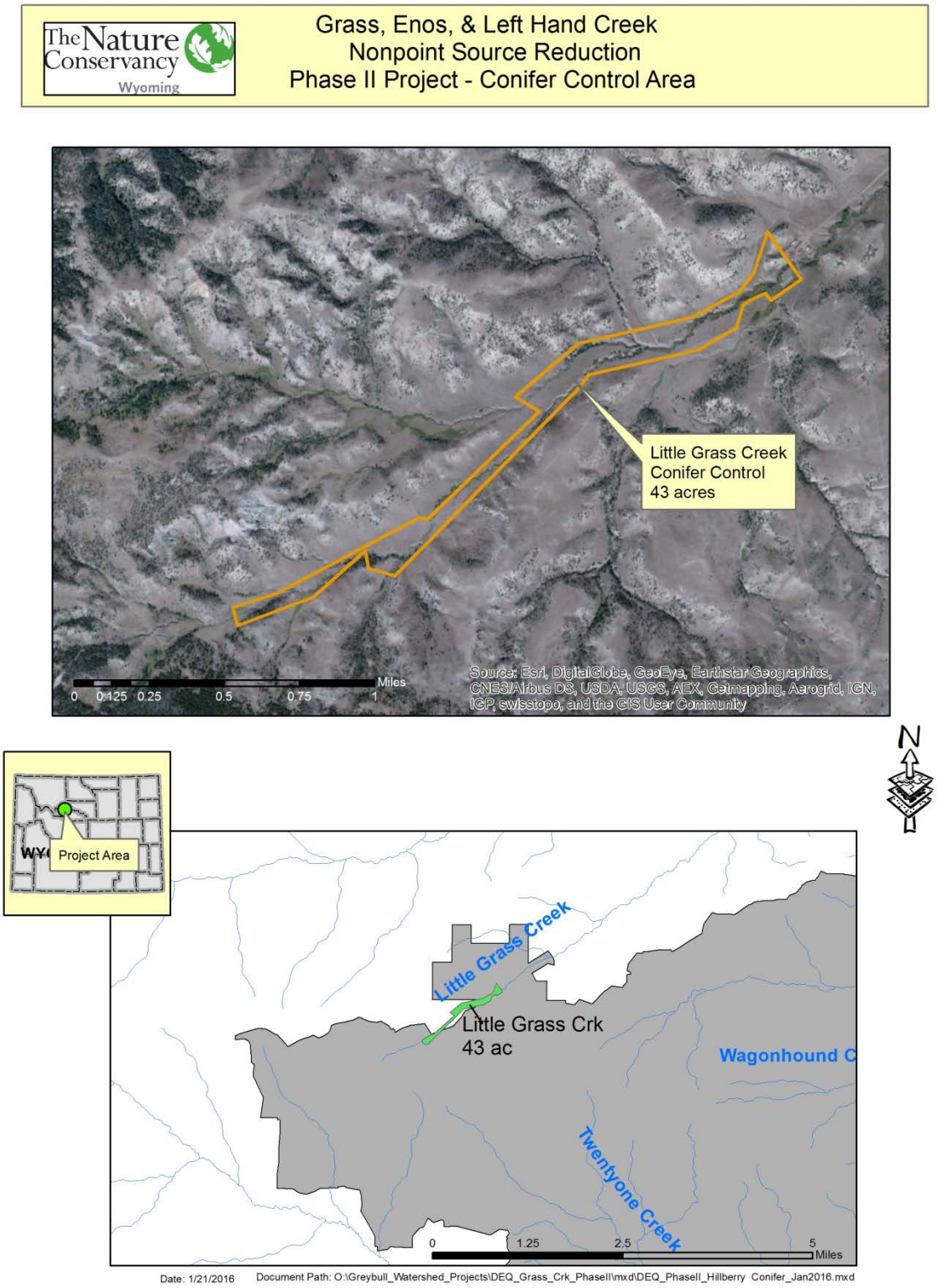


Figure 6. Conifer control completed on Little Grass Creek in Phase II.

Weed Treatment

Following conifer control on Left Hand Creek, we observed the release and expansion of musk and Canada thistle throughout the drainage. Given that weeds often outcome native species, we decided that these infestations needed to be addressed in order to fully support the restoration of healthy riparian areas in the project area. In 2015, a contractor sprayed 64 acres in the Left Hand drainage for these weeds (Figure 7).

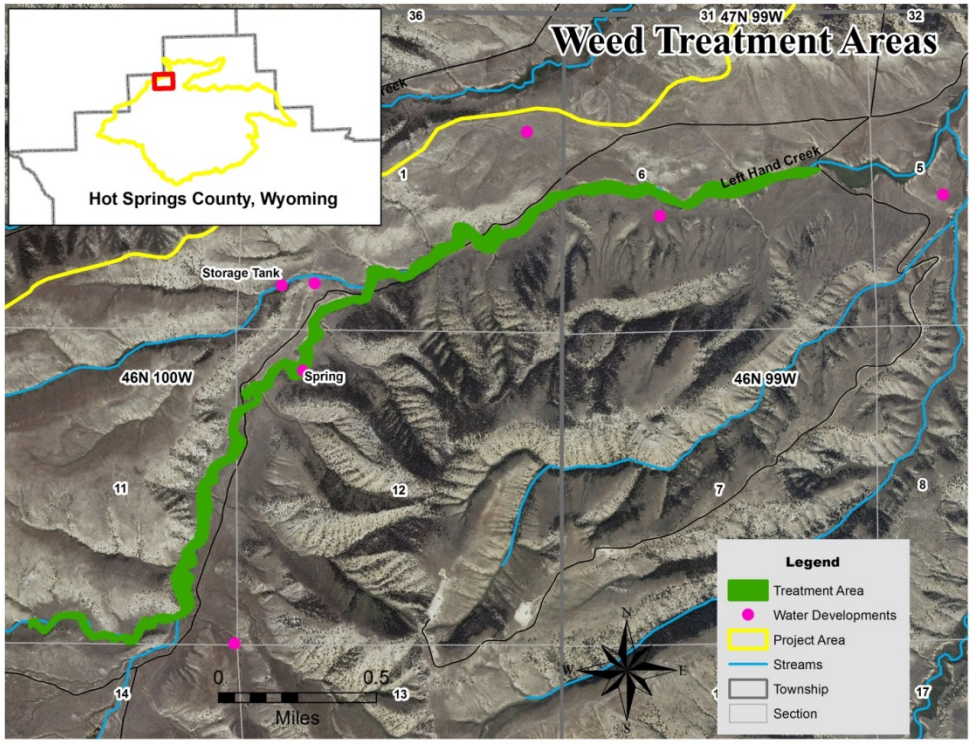


Figure 7. Weed treatment polygon on Left Hand Creek.

Water Quality Improvement through Measured or Estimated Load Reductions

Project amendments and extensions through 2015 provided more time and money to implement remaining BMPs, but not additional resources for monitoring which will be undertaken with Phase III funding. Therefore, water quality monitoring results from 2014 and 2015 will be presented in our Phase III final report. That said, since it was complete at the time of report drafting, we present the results of our final season of aquatic macroinvertebrate monitoring here because it helps to develop a fuller picture of the impacts that Phase II BMPs may have had on water quality.

We used StepL to estimate the sediment, nitrogen and phosphorus reductions achieved in Phase II for the Left Hand Creek drainage (Table 3). These calculations are made based on several factors including distance of BMP from the stream, bank heights, and use efficiency of the BMP. In Phase II, the BMPs implemented on Left Hand Creek resulted in an estimated reduction of 200.76 tons/year of sediment, 53.60 lbs/year of nitrogen, and 20.5 lbs/ year of phosphorus.

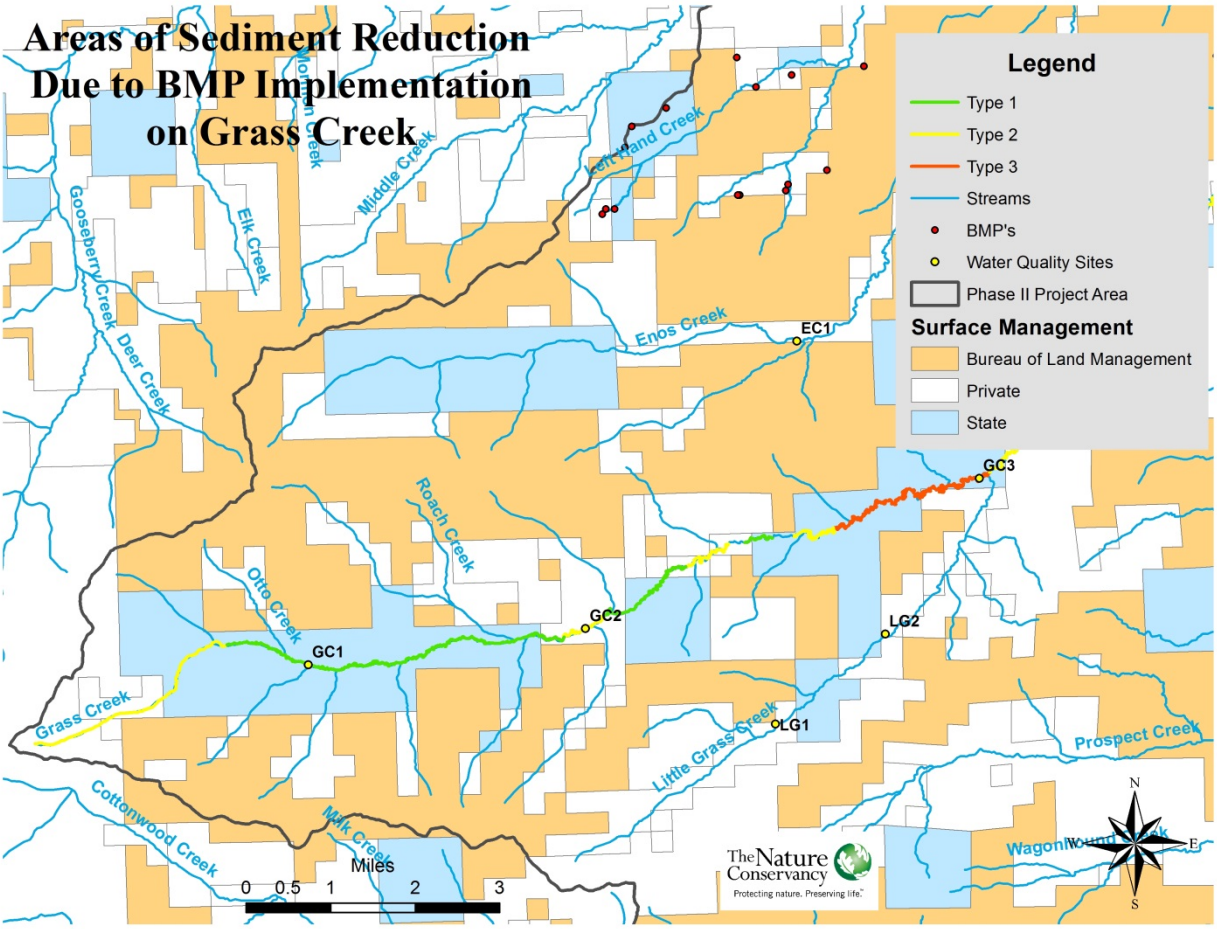


Figure 8. Erosion types on Grass Creek. Type 3 calculations were not made since BMPs were not implemented on this drainage in Phase II of the project.

Sediment loads from stream bank erosion were also measured for Grass Creek and Left Hand Creek using the Rosgen method. Two monitoring sites on Grass Creek (Figure 8), each representing a different stream type, were used to calculate erosion rates by tons/year/foot. This rate was then multiplied by the total length of each stream type to yield the estimated erosion rate for the year. Reductions calculated from this method are based on the previous year's data collected. Table 6 shows the measured decreases for Grass and Left Hand Creeks, areas where BMP implementation has focused during Phases I and II of the project.

The three types of bank classification on Grass Creek are based on the three different monitoring sites. We calculate that the upper 10 miles of Grass Creek (i.e. GC1 and GC2 Types), the portion of the drainage where BMPs were implemented, experienced a sediment reduction of 1,260.4 tons per year (roughly equivalent to 90 commercial dump truck loads per year) over Phases I and II of the project (Tables 3 and 4). Over the same time period, we also reduced nitrogen input by an estimated 29.80 lbs/year and phosphorus by 9.10 lbs/year (Table 3).

Because we did not calculate the length of GC3 Type streambank during Phase II, those numbers are not included in this report. However, those calculations will be included in our Phase III final report.

TABLE 4. Measured sediment reductions (in tons/yr) on stream reaches where BMPs were focused based on the Rosgen monitoring sites and data collected from 2010 to 2013.

Site Type	Length	2010 (tons/yr)	2011 (tons/yr)	2010 -2011	2012 (tons/yr)	2011 -2012	2013 (tons/yr)	2012 -2013	2010 -2013
GC1 Type	7.7	1830.0	1119.6	-710.4	988.3	-131.3	759.6	-228.8	**-1070.4**
GC2 Type	2.4	336.7	261.8	-74.8	201.3	-60.5	165.3	-36.1	**-171.4**
Stream Subtotals	**10.1 mi**	**2166.7**	**1381.4**	**-785.2**	**1189.7**	**-191.8**	**924.8**	**-264.8**	**-1241.8**
LH Type 1	1.7	36.6	39.2	2.6	7.2	-32.0	26.7	19.5	**-9.9**
LH Type 2	1.2	24.8	33.3	8.5	6.4	-26.9	23.6	17.2	**-1.2**
LH Type 3	9.2	197.1	265.2	68.1	9.7	-255.5	36.0	26.3	**-161.1**
Stream Subtotals	**12.1 mi**	**258.5**	**337.7**	**79.2**	**23.3**	**-314.4**	**86.3**	**63.0**	**-172.2**

Three different erosion types were identified for Left Hand Creek (Figure 9); only one erosion rate has been measured at LH1, so the other erosion rates were calculated based on the LH1 rates using the STEPL model. Erosion Type 1 is the measured erosion rate at LH1 and type 2 is very similar with the exception of bank heights. The type 2 rates were calculated using the STEPL model to change the bank height. Type 3 erosion rates are also based on LH1 measurements, but these portions of the stream are ephemeral and were only observed to flow completely about every four years; the LH1 annual rates were therefore divided by four to get the erosion measurement. On Left Hand Creek, where BMPs were implemented throughout the drainage, we calculate a total sediment reduction of 200.8 tons/year from 2010 to 2013 (roughly equivalent to 14 commercial dump truck loads per year) (Tables 3 and 4). Over the same time period, we also reduced nitrogen inputs on Left Hand by an estimated 53.6 lbs/year and phosphorus by 20.5 lbs/year (Table 3).

While we did collect bank erosion data for Little Grass Creek, we did not identify erosion types for the length of that stream, so complete calculations for sediment reduction using Rosgen monitoring data were not made in Phase II. We will include those estimates in the Phase III final report for this project.

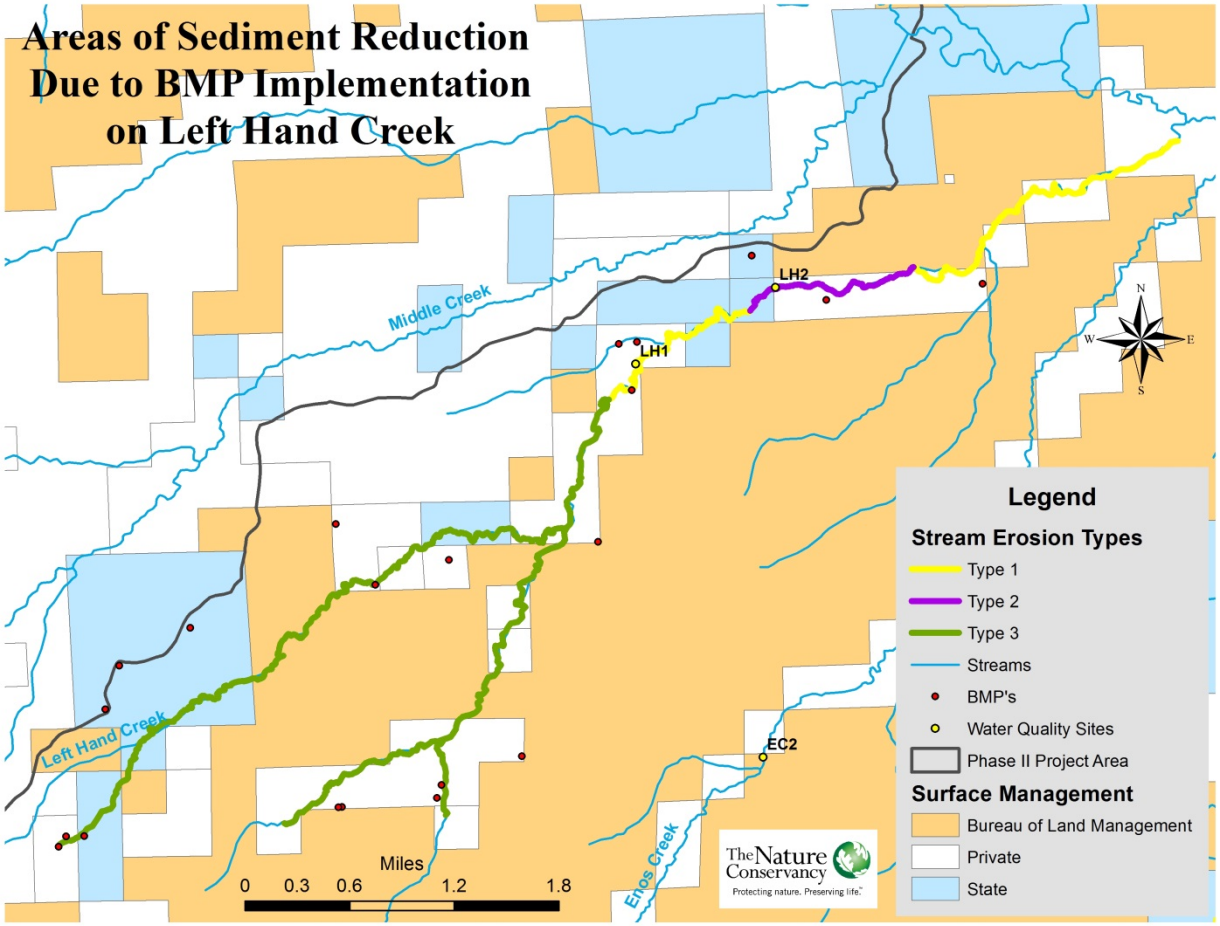


Figure 9. Left Hand Creek stream erosion types.

Despite the BMPs implemented on Left Hand Creek in Phase II, erosion increased in the drainage in 2013. A possible cause was a large flood event that occurred in July 2013 (Figures 10-12) that washed through the lower end of LH1 and down through the entire length of the type 2 erosion segment removing vegetation and decreasing substrate size. As a result of these topographical changes, macroinvertebrate sampling was not done at this site again in Phase II. Samples were taken again in 2015 under Phase III of this project. The flooding diminished our ability to measure the beneficial impacts of the BMPs implemented.

Figure 10. A view of the flooding looking up Left Hand Creek on July 14, 2013. Photo by Barbara Love.

Figure 11. Portions of Left Hand Creek usually resemble this section of stream.

Figure 12. This gravel bar is a July 2013 addition to this section of Left Hand Creek. The source of this material is the stream bank below the red X.

6.0 Monitoring Results

Water Quality Monitoring

In Phase II of the project, we continued to use the water quality monitoring program that we designed and implemented in Phase I with the goal being to track changes in water quality following BMP implementation. The Nature Conservancy Sampling and Analysis Plan for the water quality monitoring program was reviewed and approved by the WDEQ prior to the initiation of monitoring (TNC 2010). Additional details about monitoring methods and equipment can be found in that document, which is both on file with the WDEQ and available by request. Methods and complete results can be found in *Appendix A: Monitoring Results for the Grass, Enos, and Left Hand Creek Nonpoint Source Reduction Project*.

We established nine (9) monitoring sites in Phase I, which we again used for sampling during Phase II. While we had intended to add a few monitoring points in Phase II, after learning of the ephemeral nature of many of the streams in the expanded project area compounded with the long travel times to these remote areas, we decided that adding additional water quality monitoring sites was impractical.

We established three (3) water quality monitoring sites on Grass Creek, and two (2) each on Little Grass, Enos and Left Hand Creeks (Figures 8 & 9). Little Grass Creek data yields one year of baseline information before riparian fences were built in 2013 and 2014. The three Grass Creek sites each yielded one year of baseline data (2010) and three years of data following BMP implementation from 2011 to 2013. The two Left Hand Creek sites yielded three years of baseline data and one year of data following stock tank installations in 2013. We have not implemented any BMPs on Enos Creek, thus all data collected from this site is baseline data.

We performed data collection for the water quality monitoring portion of this project according to the following schedule, which is summarized in Table 7. From June-September in 2012 and 2013, we collected physicochemical and physical water quality data. Physicochemical data, including temperature, pH, conductivity, and dissolved oxygen, were collected at the end of June, July, August, and September. Physical data were collected in July or August and included measurements of bank erosion rates, riparian vegetation data from channel cross sections, and pebble counts. We also collected aquatic macroinvertebrate data in 2013 but not 2012 due to the high cost of sample analysis. We collected another series of macroinvertebrate samples in 2015 as part of Phase III of this project, and are including those data in this report to enhance our analysis of macroinvertebrate data. Lastly, we deployed two in-situ water temperature loggers per site at five sites, for a total of ten loggers. At each site, one logger measured pool temperature while the other measured riffle temperature. The loggers collected temperature data every hour from the end of June through September of each year.

TABLE 5. Summary of 2012-2013 water quality monitoring data collection schedule, broken down by site.

Site ID	June	July	August	September
GC1	Physicochemical	Physicochemical Cross-Section Vegetation Temperature Logger	Physicochemical Bank Erosion Macroinvertebrate (2013) Pebble Count Temperature Logger	Physicochemical Temperature Logger
GC2	Physicochemical	Physicochemical Cross-Section Vegetation Temperature Logger	Physicochemical Bank Erosion Macroinvertebrate (2013) Pebble Count Temperature Logger	Physicochemical Temperature Logger
GC3	Physicochemical	Physicochemical Cross-Section Vegetation Temperature Logger	Physicochemical Bank Erosion Macroinvertebrate (2013) Pebble Count Temperature Logger	Physicochemical Temperature Logger
LG1	Physicochemical	Physicochemical Cross-Section Vegetation	Physicochemical Bank Erosion Data Macroinvertebrate (2013) Pebble Count	Physicochemical
LG2	Physicochemical	Physicochemical Cross-Section Vegetation Temperature Logger	Physicochemical Bank Erosion Macroinvertebrate (2013) Pebble Count Temperature Logger	Physicochemical Temperature Logger
EC1	Physicochemical	Physicochemical Cross-Section Vegetation Temperature Logger	Physicochemical Bank Erosion Macroinvertebrate (2013) Pebble Count Temperature Logger	Physicochemical Temperature Logger
EC2	-	Vegetation	-	-
LH1	Physicochemical	Physicochemical Cross-Section Vegetation Temperature Logger	Physicochemical Bank Erosion Data Pebble Count	Physicochemical
LH2	-	Vegetation	-	-

Analysis of Physicochemical Data

Grass Creek

The pH levels we recorded between 2010 and 2013 at all three Grass Creek sites fell within the required range for acceptable water quality in Wyoming (not less than 6.5 and not greater than 9.0) as detailed in the Wyoming Water Quality Rules and Regulations, Chapter 1 (WDEQ/WQD 2013). Levels varied across all three sites during the four years with no discernible trend.

Dissolved oxygen levels also varied on Grass Creek with no discernible pattern. In 2010 and 2013, our dissolved oxygen measurements at GC1, the highest elevation site, were always above the 8 mg/L one-day minimum for coldwater fisheries (WDEQ/WQD 2013). In July of 2011 and in June, July and August of 2012 dissolved oxygen measurements dropped below this minimum. We expected DO saturation at GC1 (2,198 m elevation) to be 76% (Table 6), however our

measurements exceeded this value throughout the Phase II project period. At GC2, the middle-elevation Grass Creek site, dissolved oxygen levels dropped to 7.74 mg/L (90.5%) once in 2010 and 6.95 mg/L (81%) once in 2011. In June 2012, July 2012, and August 2013, DO levels once again dropped below the minimum. However, DO saturation remained above the expected 78% during these periods. At GC3, the low elevation site on Grass Creek, dissolved oxygen levels remained above 8 mg/L during all four years of sampling. Dissolved oxygen saturation levels at GC3 also stayed above our expectation of 79%, with our lowest measurement being 82.3% in September 2013.

In 2010 and 2011, we measured conductivity levels that increased moving downstream on Grass Creek. Our GC1 readings ranged from 248 to 345 μS/cm, GC2 from 302 to 421 μS/cm, and GC3 from 415 to 612 μS/cm. We observed this same trend when we measured conductivity again in 2012 and 2013: GC1 readings ranged from 259 to 348 μS/cm, GC2 from 296 to 445 μS/cm, and GC3 from 577 to 619 μS/cm. Though some of our conductivity readings during the latter half of Phase II were higher than measurements in previous years, the maximums only exceeded those from earlier measurements by a maximum of 76 μS/c.

Little Grass Creek

Though Little Grass Creek is classified as a 3B stream and is not required to meet coldwater fishery standards, we still employ those standards to assess stream health. At LG1 and LG2, we recorded pH values ranging from 8.1 to 8.5 in both 2010 and 2011. In 2012 and 2013 pH ranged from 8.2 to 8.5. Throughout the project period, pH values at all sites fell within the acceptable range for Wyoming coldwater fisheries.

At the Little Grass sites, dissolved oxygen fell below the 8 mg/L threshold in June and July of 2010, July 2011, July 2012 and July and August 2013. We found DO saturation to drop below our expected value of 78% for LG1 once during Phase I and three times during Phase II (July 2012, July 2013, and August 2013). At LG2, we similarly found DO saturation to fall below our expectation of 79% once during Phase I (July 2010) and three times during the Phase II project period (September 2012, July 2013, and August 2013.

We measured conductivities at LG1 and LG2 ranging from 464 and 625 μS/cm in 2010 and 2011, and from 545 to 688 μS/cm in 2012 and 2013.

Left Hand Creek

Left Hand Creek is also classified as a 3B stream. Much of it is spring fed and portions of it are ephemeral throughout most of the year. Site LH1 is located below a spring that was developed in 2012 to provide water to four stock tanks and the system was in operation starting in late 2013. During Phase I, we measured pH values ranging from 8.0 to 8.6 in 2010 and 8.0 to 8.3 in 2011. During Phase II, we measured the same range of 8.0 to 8.3 in 2012 which dropped slightly to a range of 7.9 to 8.2 in 2013. All of these measurements fell within the acceptable range for Wyoming coldwater fisheries.

At LH1, we found that DO measurements only fell below the 8 mg/L limit for coldwater fisheries once in June of 2010 during Phase I. Throughout the remainder of both Phase I and

Phase II, DO measurements exceeded this minimum. We measured DO saturation levels ranging from 78.6% to 84.2% in 2010, and 81.8% to 101.5% in 2011. In 2012 and 2013 we found our DO saturation measurements dropped below our expected value of 80% (Table 6: site elevation is 1,859 m) once in September 2013.

Throughout the Phase II project period, we measured the highest conductivity levels of any monitoring site at LH1, suggesting a relatively high concentration of total dissolved solids in upper Left Hand Creek. In 2010, conductivity levels ranged from 1,395 to 1,471 μS/cm, which were the highest values of any site during Phase II. We found 2011 conductivity measurements at LH1 to be only slightly lower, ranging from 1,260 to 1,385 μS/cm. In 2012, conductivity ranged from 1,360 to 1,385 μS/cm. Finally, in 2013, conductivity ranged from 1,326 to 1,359 μS/cm. Though LH1 conductivity levels did not decrease over the Phase II period, the variation in conductivity levels decreased over that time.

Enos Creek

Through Phases I and II of the project, pH levels on Enos Creek were found to be within acceptable limits for a class 2AB stream (WDEQ/WQD 2013, Chapter 1 criteria). In 2010 and 2011, pH at EC1 ranged from 6.5 to 9.0. In 2012 and 2013, pH ranged from 8.1 to 8.3.

In both 2010 and 2011, dissolved oxygen levels at EC1 consistently exceeded the coldwater fisheries one-day minimum, falling to lows of 8.37 mg/L in 2010 and 8.51 mg/L in 2011. In June and July of 2012, these levels fell below the 8 mg/L minimum to 7.23 and 7.89 mg/L, respectively. The expect DO saturation level at EC1 is 79% (Table 6: site elevation is 1,981 m). DO saturation fell below this level in July of 2010, when it reached 77.8%. Our next lowest DO saturation measurement was 79.4% measured in September of 2013. Due to equipment malfunction and repair time, we do not have DO data for August 2011 or June 2013.

Our conductivity measurements for EC1 ranged from 415 to 612 μS/cm in 2010, and from 461 to 556 μS/cm in 2011. In both years, we observed an increase in conductivity from June to September. In 2012 and 2013, conductivity readings ranged from 522 to 607μS/cm, with September readings dropping slightly below the August highs.

The complete physicochemical data set collected in project area streams from 2010 to 2013 can be found in *Appendix A*.

TABLE 6. Expected Dissolved Oxygen % Saturation at each Site

Site	Elevation (m)	Expected % DO
GC1	2198	76
GC2	2069	78
GC3	1920	79
LG1	2060	78
LG2	1989	79
LH1	1859	80
EC1	1981	79

Analysis of Temperature Logger Data

We analyzed temperature logger data to determine how many days the water temperature was above the coldwater fisheries minimum of 20°C (WDEQ/WQD 2013). Additionally, we examined these data to determine if the number of days on which water temperature exceeded 20°C decreased from 2010 to 2013 (Table 7). Missing logger data in 2010 and 2011 (Phase I) was caused by logger malfunction. In 2013, we found that the loggers had not been working for the first nine days of deployment. Based on trends we observed in July data from previous years of monitoring, we inferred that those nine days likely exceeded the 20°C limit. We have included those days in our annual total for 2013. Complete daily high and low temperatures for 2010 through 2013 and comprehensive temperature logger data sets are included in *Appendix B: Compilation of Raw Monitoring Data.*

TABLE 7. Number of days during which water temperatures exceeded 20°C at each site. The asterisks indicate that there were days

Site ID	LOGGER ID	2010	2011	2012	2013
GC1	GC1TL1 - Pool	26	38	64	26*
	GC1TL2 - Riffle	23	38	60	52*
GC2	GC2TL1 - Pool	46	9*	64	42*
	GC2TL2 - Riffle	38*	53	69	53
GC3	GC3TL1 - Pool	16	14	10	44*
	GC3TL2 - Riffle	19	17	46	47*
EC1	EC1TL1 - Riffle	0	0	27	26*
	EC1TL2 - Pool	0	1*	22	24*
LG2 **	LG2TL1 - Pool/Run	37	8	54	23*
	LG2TL2 - Riffle	47	25	65	29*

* Days during monitoring season when loggers were not functioning.
** As a 3B stream, Little Grass is not expected to maintain water temperatures above the coldwater fisheries minimum.

Our results revealed that temperatures in 2010 and 2011 for all three drainages were consistently too high to support healthy coldwater fisheries. With the exception of the GC3TL1 logger on Grass Creek, we found this to be true again in 2012 and 2013. We also found the number of days during which stream temperatures exceeded 20°C increased significantly from 2011 to 2012. Regarding the GC3TL1 logger, logger pairs at a site usually measure similar temperatures, and, resultantly, yield similar results for number of days exceeding 20°C. In 2012, however the difference between GC3TL1 (10 days above the limit) and GC3TL2 (46 days above the limit) was 36 days. The logger was functioning properly when calibrated before and after the season. We reviewed the data, and a possible explanation for this large difference is extra cover and depth of the pool where GC3TL1 is located. However, this pattern was not repeated in 2010, 2011, or 2013.

A secondary objective of Phase II was to reduce stream temperatures throughout the project area by lessening the impact of cattle usage in riparian areas, in order to benefit trout. Though our temperature logger results for Phase II did not reflect any decreases in water temperatures, we expect to see results in years to come. Over the course of Phase II we planted 3,800 willow pole

cuttings to create more cover above the water column, however we will likely not see impacts from these plantings for several years until the trees have had a chance to become established. Higher stream temperatures observed during the project period, and especially in 2012, were likely due to drier conditions in the basin. During dry years, stream depths decrease, resulting in temperature loggers being deployed in shallower water. Deployment in shallow water results in temperature loggers being more impacted by air temperatures.

One flaw with our project design is that many of our monitoring sites are located a significant distance from the implemented BMPs. None of our temperature loggers, for example, were deployed in areas where willow growth or cattle exclusion would directly impact them.

Analysis of Physical Data

Vegetation

The goal in collecting vegetation data was to monitor riparian and near riparian vegetation to determine if the BMPs we implemented during the project period are positively impacting surrounding areas. The vegetation was categorized as perennial, annual, or noxious grasses or forbs, shrubs, sedge/rush, litter, moss/lichen, rock, bare ground, willows, or riparian trees. In 2010 and 2011 we collected vegetation data using percent cover by species measurements. When comparing the four years of data we had collected, we discovered that we had made errors misidentifying species and decided to instead use percent cover by life form. This change allowed us to compare all sites over the four-year period. For example, at the LG2 site in 2010 we could not identify many of the perennial grasses and labeled them generally as PG whereas in 2012 many more species were identifiable. This change may have influenced our data set to reflect a false increase in species present. Comparing the results by life form eliminated this false result. The transects span between 50 and 100 feet on either side of the riparian area in order to enable us to measure any expansion of the riparian vegetation resulting water table rise following BMP implementation. Our goal was for healthy sites to maintain or increase perennial grasses and forbs, sedge/rush, litter cover, riparian trees, and shrubs beyond the immediate riparian area. An additional goal for this portion of the project was for bare ground and noxious grasses and forbs, if present, to decrease or disappear. Graphs of the ground cover data are located in *Appendix A*.

Little Grass Creek

The vegetation on Little Grass Creek remained in a mostly static condition over the sampling period from 2010 to 2013, with the exception of two significant changes. Bare ground cover at LG1 decreased from 12.1% in 2010 to 1.2% in 2013, indicating improvement for that area. The other notable vegetation dynamic in the Little Grass Creek drainage concerns the relative proportion of litter to perennial grass. In 2010 and 2012 the proportions of litter to perennial grass are high, while in 2011 and 2013 they are low. This is best explained by the grazing rotation; in even years, cattle graze the pasture before and during sampling, resulting in an increased proportion of litter to grass. In odd years, cattle are not turned out into these pastures until winter (after sampling is completed), thereby explaining why proportions of litter to vegetation are lower in odd years. It’s important to note that while perennial grass is preferred, a

prevalence of litter does not indicate degradation of the vegetative component in the same way that bare ground does. Throughout the project period, bare ground decreased at the upper LG site and disappeared entirely at the lower LG site. We observed a very small percentage of noxious forbs at both Little Grass Creek sites in 2011, which decreased even further by 2013.

Grass Creek

We measured very little or no bare ground on GC1, GC2, and GC3. GC1 had 6% cover of noxious forbs in 2010, which decreased steadily to 2.2% in 2013. We did not record any noxious forbs at GC2, while GC3 featured a 10% cover of noxious forbs throughout the project period.

Enos Creek

At the upper Enos Creek monitoring site, EC1, perennial grasses increased from 40% cover in 2010 to almost 60% in 2013. Sedges and rushes, however, declined over that same period from 40% cover in 2010 to less than half that 4 years later. Annual grasses and noxious species were essentially nonexistent at this site, and bare ground was minimal to nonexistent here as well.

We saw similar patterns at the lower Enos Creek site, EC2, where perennial grasses doubled from roughly 15% to 30% cover while sedges and rushes declined from 50% to 20% cover over the four-year study. Noxious forbs declined slightly over the study period from a high of ~ 25% cover in 2011 to 17% cover in 2013. As seen elsewhere, litter levels peaked in 2012 at both Enos Creek sites.

Left Hand

While monitoring LH1, the upper site on Left Hand Creek, we observed about 2.6% noxious forb coverage in 2010, which we found increased to 5% in 2013. We also observed bare ground at this site in 2011 and 2012, but none in 2013. At LH2, the lower site, we observed noxious grasses and forbs present since 2010 throughout the duration of the project. The primary noxious grass at this site is cheat grass (*Bromus tectorum).* We observed a decrease in percent cover of cheat grass from 2012 (13.4%) to 2013 (12.2%). The very low cover in 2012 resulted from the early drying and breaking off of the plant - the same reason litter was increased that year. We also noted noxious forb presence at this site throughout the duration of Phase II, with their highest percent coverage being 10% in 2013.

While our vegetation monitoring results have not yet indicated any significant expansion of the riparian area, neither did they reveal a decrease in riparian area health at any of our monitoring sites. Bare ground decreased at several of our sites indicating improved vegetative condition over time. As range monitoring continues to provide the LU with better information about grass utilization, cattle become familiar with the locations of new off-creek water sources, and pole plantings become established in the riparian areas, we would anticipate our vegetation transects to reveal improving trends over time.

Stream Bank Erosion

We collected bank erosion data at seven water quality sites, as identified in Table 5. A complete description of our methods is available in *Appendix A*. Table 10 shows a summary of the erosion rates at each of these sites and changes we observed over the course of the project.

At the two upper Grass Creek sites, GC1 and GC2, erosion rates decreased in all four years that data were collected. These sites, nearest to Phase I BMP implementation, showed decreased erosion rates over 50%; GC1 declined by 54.4% and GC2 declined by 51.0%. Although no BMPs were implemented near GC3, the lowest Grass Creek site, over the course of the project, erosion decreased at this site by almost 19%. We measured reductions of 22% in 2012 and 25% in 2013. It is possible that range monitoring influenced utilization and grazing timing at the site, resulting in erosion reductions. Overall, we measured significant erosion reduction at our Grass Creek monitoring sites.

The highest site on Little Grass Creek, LG1, showed significantly reduced erosion in 2012 and 2013 with a decrease of 48% over Phases I and II of the project. At the lower Little Grass Creek site, LG2, erosion increased initially before decreasing significantly in 2012 and 2013 for a life of project erosion decrease of 56%. Overall, erosion rates at our Little Grass Creek sites declined significantly between 2010 and 2013.

Erosion rates at site EC1 on Enos Creek increased by about 74% over the four-year period. This is the only site where we measured increased erosion rates over the life of the project. All of the other sites exhibited overall decreases in erosion rates from the beginning of Phase I to the end of Phase II of this project. Enos Creek is also the only drainage where we measured erosion rates but did not implement any grazing BMPs.

Left Hand Creek also had an overall decrease in erosion rate of 7% at the only site where we were measuring it on that stream. The decreasing sediment loads suggest that the Phase II BMPs implemented are positively impacting this stream, although those positive impacts may be getting overwhelmed by other influences in the drainage. LH1 showed a moderate increase from 2010 to 2011, a significant decrease in 2012 (the drier year), and then a significant increase in 2013. The large increase occurred after BMPs were implemented in the pasture, but management practices were likely not the cause. During a severe thunderstorm in July 2013, a flash flood down a side drainage and through the study reach creating a new gravel bar in the reach. The flood washed about 30 cubic feet of sediment and gravel into the stream from the side drainage, deposited sediment and debris downstream, and washed out or covered much of the stream bank vegetation (Figures 10-12).

TABLE 8. Estimates of tons per year of sediment eroding from stream banks at each monitoring site from 2010 to 2013.

Site	2010 (tons/yr)	2011 (tons/yr)	2012 (tons/yr)	2013 (tons/yr)	Change from 2010 to 2013 (tons/yr)	% Change 2010 to 2013
GC1	16.2	11.07	9.6	7.38	-8.82	-54%
GC2	9.57	7.45	5.72	4.69	-4.88	-51%
GC3	17.74	24.48	19.2	14.41	-3.33	-19%
LG1	3.49	2.44	2.01	1.81	-1.68	-48%
LG2	0.5	0.52	0.48	0.22	-0.28	-56%
EC1	5.63	9.61	10.15	9.77	4.14	74%
LH1	1.51	2.03	0.31	1.41	-0.1	-7%

Ratios of Study Bank to Bankfull Heights

At seven main monitoring sites (excluding EC2 and LH2), we measured study bank and bankfull heights at both the start and the end of each reach. The ratio of the study bank height to bankfull height (SB/BKF) can be used to indicate streambed stability, aggradation, or incision. TNC staff received training in 2010 and 2012 on how to properly take this measurement. In 2011 we took several measurements improperly, which caused our results to indicate significant incision that was not otherwise indicated by our other data. Therefore, we will not use 2011 data for our analysis and are considering these data anomalous. We are confident that 2010, 2012, and 2013 data were taken correctly, and we will use those data for our analysis.

Measurements recorded at LG2, GC1, GC2, and GC3 all indicated that these sites were stable and were not incising or aggrading. In 2010 our measurements indicated that there may have been some incision occurring at LG1, but the ratios measured in 2012 and 2013 indicated increased stability. SB/BKF ratios at EC1 indicate that aggradation occurred in 2010 and 2012. In 2013, however, the site showed increased stability with similar top and bottom measurements. LH1 ratios also indicated that the stream was aggrading in 2010 and then stabilized in 2012 and 2013. The complete data table is located in *Appendix A.*

Substrate Distribution

We collected substrate distribution data from a riffle within the study reach at each site at the same location every year. We performed a pebble count of 100 particles within each reach, classifying each particle by the length of its second-longest axis. Graphical results are presented in *Appendix A: Monitoring Results*. We expected average particle size in project area streams to increase over time as erosion of fine sediment decreased following BMP implementation.

Little Grass

On upper Little Grass Creek, at site LG1, we observed a decrease in particle size over the study period. Between 2010 and 2013, sand and silt comprised 1% of the substrate sample (2010), spiked to 25% (2011, dropped to 16% (2012), and increasing once more to 49% (2013).

On lower Little Grass Creek, at site LG2, we observed only a very slight increase in particle size over the course of the project. In 2010 and 2011, 100% of the particles we sampled were sand and silt. In 2012, 93% of samples were sand and silt, and in 2010, 97% were sand and silt.

Enos Creek

We found that particle size decreased on Enos Creek over the course of the project as measured at site EC1. Particle size decreased slightly between 2011 and 2012, and at a higher rate between 2012 and 2013.

Grass Creek

Substrate distribution data collected at the upper Grass Creek site, GC1, indicated a slight decrease in particle size in 2012, with more sand and silt particles being present, though our samples still included particles that fell within the large cobble category. In 2013, we observed a measureable decrease in particle size, with coarse gravel (16-22.6 mm) being the largest category of particle size sampled. That year, over half of the samples we collected at GC1 fell within the four smallest size classes.

At the mid-elevation Grass Creek site, GC2, we observed an increase in particle size in 2012, with more particles falling within larger size classes than in the previous two years. However, this trend reversed by 2013. In 2012, 67% of particles collected were coarse or very coarse gravel, while in 2013, 68% of particles measured were silt to 4 millimeters in size.

On lower Grass Creek, at site GC3, average particle size decreased between 2011 and 2012, and decreased again from 2012 to 2013. Our theory to explain why substrate size may have decreased on Grass Creek, in contrast to expectations, is found below.

Left Hand

In 2010 at LH1, we sampled a normal distribution of particle sizes, with most samples falling within the fine- and medium-gravel categories. In 2011, we observed a shift in particle distribution towards larger particle sizes, with most samples falling in the coarse- and very-coarse gravel categories. In 2012 and 2013, during the Phase II project period, however, particle size distribution shifted dramatically toward the finer particle size classes, with the majority of samples taken in both years falling into the silt and sand categories.

Contrary to expectations, we observed a shift towards smaller particle sizes in project area streams during Phase II of the project. There are a few possible explanations for these observations. As noted elsewhere in this report, drier conditions in 2012 resulted in relatively low vegetative cover at several sites in the project area. In 2013, 7 localized, severe thunderstorms occurred that impacted both Left Hand Creek and the upper to middle Grass Creek watershed. These storms occurred on July 13, July 28, August 7, August 9, August 12, August 22, and August 30 (NOAA, 2015). Records show that between these storm events, the area experienced frequent light rain, which likely dampened the highly erodible and (typically)

dry soils within those watersheds. These damp conditions combined with the intense storm events likely resulted in overland flow that washed large volumes of fine sediments and small-to-mid-size gravel into the study streams.

Had the fine sediments been the result of streambed or bank erosion, we likely would have observed a marked increase in sand and silt in the Grass Creek sites, rather than the increase in small- and mid-size gravel that we observed. The observed shift towards finer sediments in both Left Hand Creek and Grass Creek, coincident with several intense storms, suggests that the sediment shift in both of these watersheds may have been the result of isolated weather patterns, rather than bank instability.

A second potential contributing factor involves disturbances in both watersheds. On Grass Creek and its tributaries, significant beetle kill, a multi-year salvage logging operation, and a number of associated culvert replacements and other road repairs may have contributed to sediment movement in the drainage. Over the same period, the Left Hand Creek drainage has also seen disturbance due to the implementation of project BMPs. Bare ground exposed during the installation of off-creek water sources and the mechanical removal of encroaching conifers from riparian area could also have contributed fine sediments to the stream.

Analysis of Biological Data

We collected biological data from the same designated riffle within each study reach where we collected physical and physicochemical data. A complete description of the methods we used can be found in *Appendix A*. We compared results using Wyoming Stream Integrity Index (WSII) scores (Hargett, 2011). During Phase II, we collected macroinvertebrate samples from all study streams in 2013 with the exception of Left Hand Creek (where severe flooding in the summer of 2013 removed our study riffle – see Figs. 10-12 and the Substrate Distribution section for details). WDEQ staff advised that a similar riffle be sampled on Left Hand Creek, however the flood impacted all other suitable sites. We collected macroinvertebrate samples again in 2015 and although this was Phase III of the project, our analysis here includes those results to enable us to make better-supported conclusions about macroinvertebrate community dynamics in the study streams. Figure 13 shows WSII scores yielded from macroinvertebrate samples collected between 2010 and 2015.

Grass Creek

Over the course of the project, only three samples from two sites have ever scored a Full Support rating for macroinvertebrates - at the upper Grass Creek site in 2015, and at the lower Grass Creek site in 2010 and 2011. GCI showed small improvements between 2010 and 2013 before showing a large improvement in 2015. The improved scores at this site may reflect the beneficial impacts of BMPs implemented in the upper portions of the drainage in both Phases I and II.

In contrast to the upper site, the scores at the mid-elevation Grass Creek site, GC2, were stable in 2010 and 2011, declined in 2013, and then rebounded in 2015 to where they'd started. At the lowest site, GC3, scores improved initially before declining from Full Support Indeterminate range in 2013 and 2015. This site showed the most significant decline in conditions of any in the

study area over the course of the project, perhaps reflecting the fact that no BMPs were implemented anywhere near this site during the project.

The middle Grass Creek site has remained in similar condition throughout the project period, while the lower Grass Creek site, GC3, has shown a decline in biological conditions since 2010. These conditions are likely the result of excess in-channel sediment being periodically flushed out of the stream channel. As our physical results have indicated improving bank and riparian conditions along Grass Creek, this sediment is likely a pre-existing excess sediment load that is being slowly processed by the stream.

Little Grass Creek

WSII scores for LG2 indicated improvement in the site's ability to support macroinvertebrate life initially, followed by decline in Phase II the project. The measurable decline we saw in biological conditions across Little Grass and Grass Creeks in 2013 was likely due to the intense thunderstorms described in our Substrate Distribution analysis. This hypothesis is further supported by the fact that WSII scores showed improvement from their 2013 levels in 2015.

Enos Creek

WSII scores for the Enos Creek site, EC1, indicated Partial or Non-Support throughout the study period with very little variation. No BMPs were implemented either above or near this site during the project.

Left Hand

Left Hand Creek, sampled in 2010, 2011 and 2015, showed declining biological condition over time, with the most significant decline measured in 2015. A flash flood triggered by localized storms prevented aquatic macroinvertebrate sampling in Left Hand Creek in 2013. The storms likely triggered an influx of overland flow into the streams, which we believe washed with it high amounts of fine sediments, which would have negatively impacted many aquatic macroinvertebrate communities. This hypothesis is further supported by the immense improvement in conditions at LG1, LG2, GC1, and GC2 between 2013 and 2015.

Our analysis also included an assessment of the prevalence of EPT taxa (*Ephemeroptera*, *Plecoptera*, and *Trichoptera* community attribute) in project area streams. The presence and prevalence of mayflies, stoneflies and caddisflies in a stream are a strong indicator of water quality because many taxa of these insects area sensitive to poor stream conditions. Between 2010 and 2015, the EPT metric for our aquatic macroinvertebrate samples has improved, indicating an increase in the diversity of sensitive taxa within the project area. Over the same period, our Hilsenhoff's Biotic Index (HBI) also improved. HBI measures the organic-pollution tolerances of taxa found in macroinvertebrate communities. Our improved HBI metric indicates an increasing component of sensitive taxa in the macroinvertebrate communities throughout the project area.

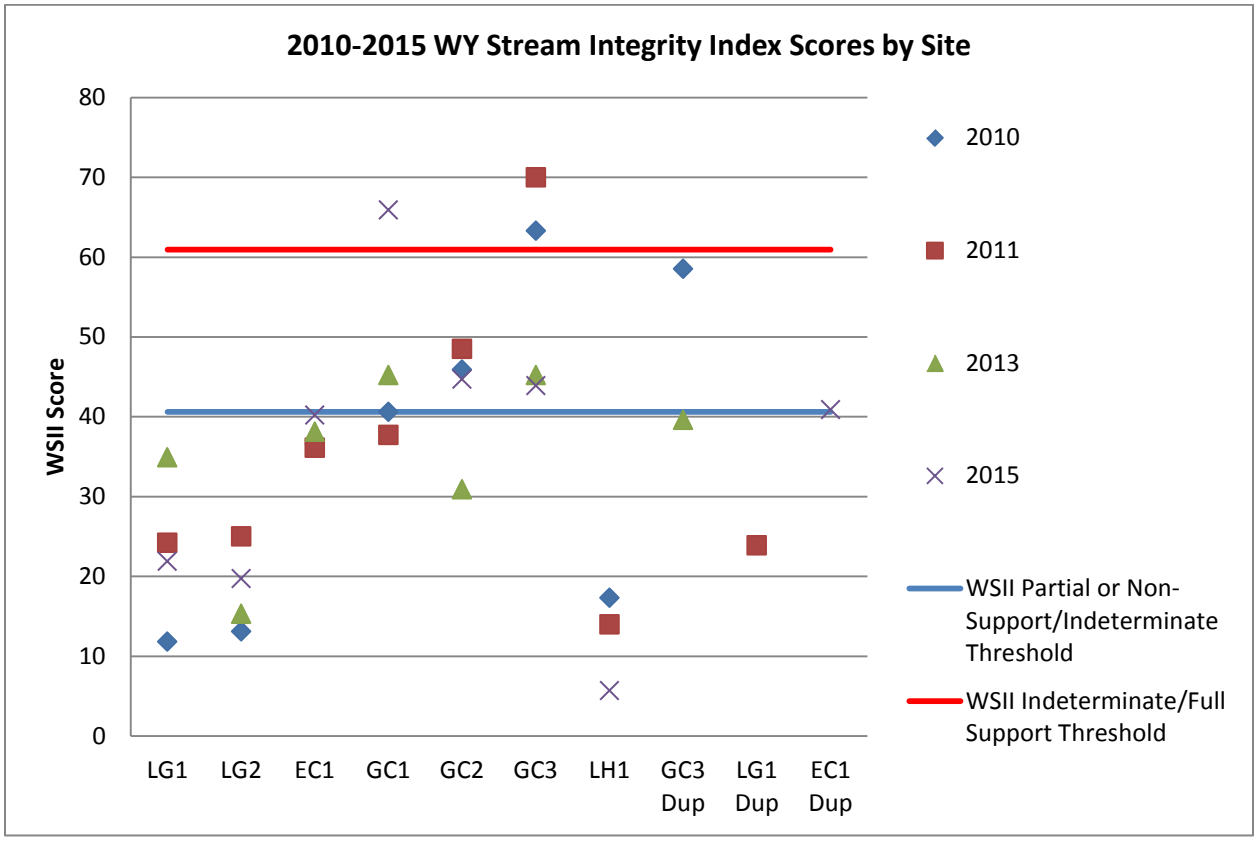


Figure 13. Categorized site scores from the WSII model. (*Note: The score from EC1 in 2010 is clustered with the scores from 2011 and 2013, so it is difficult to see the symbol on this figure.)*

Analysis of Aspen Stand Monitoring Data

Aspen trees are a preferred species for beaver as they provide food and dam-building material. One objective of this project is to facilitate the migration of beaver back into the upper elevations of project area drainages. As such, some of our work since the project began has been aimed at improving the health of aspen stands in the project area. In Phase I, we built two exclosures around struggling aspen stands with the intention of excluding both wild and domestic animals. These six-foot tall, seven wire fences were very effective at excluding grazers and browsers; only a couple times have animals gotten into the exclosures since they were finished.

Following the completion of our aspen protection fences during the Phase I project period, we worked with project partners to create a monitoring plan to assess the effectiveness of our fences in promoting aspen regeneration. This work was not funded through this project, but the results are obviously relevant to the project. We used methods described in a USDA publication (Jones *et al.*, 2005). Our monitoring method involved the establishment of twenty-one permanent belt transects through the protected aspen stands, and twenty-one belt transects through unprotected aspen stands located in the same area. Along the transects, we counted the number of trees present in height classes ranging from just sprouted up to six feet tall. We collected data from the transects in 2011 and 2012. The data we collected in 2011 and 2012 did not indicate that the fences were improving stand regeneration (Figure 14), however two years of data are not

sufficient to indicate any significant change. Further, the fences were completed in June of 2011 and the monitoring did not commence until late August of 2011, and although the paired aspen stands were similar prior to fence construction, they were quite different by the time we began collecting data. We believe that baseline data would provide a much better picture of the impacts of the aspen fences on the health of the stands.

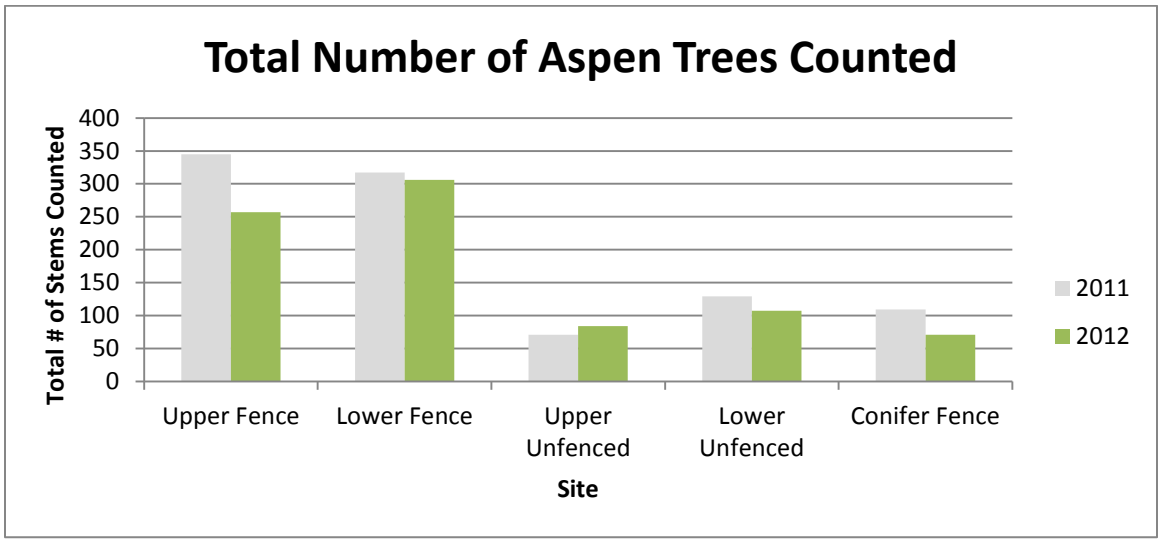


Figure 14. Aspen stems counted inside and outside exclosures.

Analysis of Range Monitoring Data

During Phase II of this project, we worked with landowners to establish range monitoring programs and to begin employing those methods in the field. Methods and general summaries provided us by the landowners are included in this report. In Phase III, we will analyze results, and present any emerging trends and possible ties to BMP implementation.

The LU and Hillberry Ranches have shared their data with BLM range staff with whom they have worked to make adjustments to their grazing and utilization rates over time. Because modifications to stocking rates or turn-out timing must be made in concert with BLM, change can be slow and improvements incremental.

LU Range Monitoring

Seventeen range monitoring sites were established and monitored under Phase I of this project (Figure 15). These data are presented in the Phase I Final Report. To the extent possible, ranch staff monitored all 17 transects again in both 2012 and 2013, although weather and road conditions sometimes made timely access impossible. Range monitoring methods on the LU Ranch included, 1) the Landscape Appearance method to evaluate utilization of herbaceous plants, 2) permanent photo point transects to visually record range condition, and 3) the Grazing Response Index (GRI) to quantify plants' responses to grazing.

To the extent possible, the LU Ranch monitor collected permanent photo point transects and GRI numbers every year prior to cattle turn-in and soon after removal. Landscape Appearance was

assessed every other year. The 2010-2013 data is compiled in *Appendix C: LU Ranch Range Monitoring Data.*

During Phase II, all of the LU's monitoring data was thoroughly reviewed by BLM range monitoring experts during the ranch's grazing permit renewal process. Their conclusions can be found in the document Rangeland Health Assessment for the LU Ranch dated February 2015 included at the back of *Appendix C: LU Ranch Range Monitoring Data*. In summary, BLM range specialist, Cam Henrichsen, submitted the following (abridged) comments about the LU range condition:

> *[As of December 2015,] the full permit renewal through the NEPA process has not been completed yet… We renewed the permit under our Congressional Rider authority, which gives us time to complete the rangeland health assessment process and the NEPA. We started the rangeland health assessment work in 2012… We issued the Rangeland Health Assessment last spring… Our determinations for the 6 rangeland health standards are on pages 65-70.*
>
> *In summary, we concluded that the upland vegetation and soils were meeting the rangeland health standards. Our wildlife biologist failed a few sagebrush areas for wildlife, due to antelope severely overgrazing the sagebrush. Nothing related to livestock grazing. Our hydrologist failed 1 riparian segment in Roach Creek that we hope to address this next summer… Other than the Roach Creek segment, we found no issues with current livestock grazing.*
>
> *The environmental assessment to fully process the permit renewal is in final review with our NEPA coordinator right now. Hopefully the permit renewal decision will be issued in the next 30 days or so. In our stocking rate analysis for the EA, we did conclude that Units 2 and 3 are potentially stocked higher on the permit than what is available. However, our suggested stocking rate is still higher than what the ranch is using, so they had no problem reducing the permitted stocking level in those units (paper AUMs). In the EA, we will also combine the North Grass Creek Allotment that they acquired a few years ago with the LU Allotment, and adjust the permitted use dates in each unit to better suit the ranch. I don't "anticipate" any protests or appeals when we issue the decision, but you never know. We are very happy with current management.*

Hillberry Ranches Range monitoring data

TNC also contributed funds to assist the Hillberry Ranches (including Spring Gulch Cattle Company and Prospect Land and Cattle) in developing a range monitoring program. The complete range monitoring data set is found in *Appendix D: Hillberry Ranches Range Monitoring Data*.

The following status reports, submitted by the Hillberry Ranches with the support of private range consultants, outline the establishment of the range monitoring program on these ranches:

Status Report, December 16, 2013, Submitted by Dee Hillberry
Four joint meetings were held with the BLM, Hillberry Ranches, Meeteetse Conservation District, and a team of private Range Consultants to develop a comprehensive monitoring plan for the Hillberry Ranches. Subject plan was submitted to the Department of Agriculture and The Nature Conservancy.

Eleven field trips were conducted during the year to establish and collect data on16 line-intercept transects. The BLM, Range Consultants, Meeteetse Conservation District, and Hillberry Ranches attended these on-the-ground monitoring trips. A training session on the Landscape Appearance monitoring technique was held to train ranch personnel in this method of monitoring utilization. Four pastures were monitored for utilization using the Landscape Appearance method. It is expected that this monitoring program will contribute to better decisions on pasture rotation, water distribution projects, and stocking rates.

Status Report, December 12, 2014, Submitted by Dee Hillberry

Continued progress was made during 2014 on the Hillberry Ranches Monitoring program. Four additional line-intersect transects were established and run in 2014. These transects were established jointly by the BLM and Hillberry Ranches. Derek Trauntvein, BLM Range Specialist, and Dee Hillberry, Owner, evaluated each pasture and agreed upon locations of each of these transects considering topography, distance from water, and traditional trailing. New transects were located in Haynes, Hamilton Dome (2), and East Dugout Pastures. Trauntvein read and recorded the data from transects in the Haynes Pasture and Hamilton Dome East. Don Tranas and Earl Jensen (Range Consultants) and Dee Hillberry read the transects in Hamilton Dome West and the East Dugout Pastures. With the addition of these 4 transects, there are now a total of 20 line-intercept transects established. Photos and data have been recorded and filed with the BLM and Hillberry Ranches. It will be determined jointly between the BLM and Hillberry Ranches when these Transects will be re-read and at what frequency.

The major effort during 2014 was completing the Landscape Appearance Monitoring program. Photos were taken prior to cattle turn-in and following departure on each pasture as well as the Landscape Appearance data recorded on each pasture.

Two training sessions were conducted in the field with Derek Trauntvein (BLM), and Don Tranas and Earl Jensen (Range Consultants) serving as trainers. Dee Hillberry (Owner), and Wyatt and Jake Agar (Lessees) participated in the training. During the course of the grazing season a total of 13 pastures were monitored using the Landscape Appearance method. The Lessees monitored 11 of these pastures and Dee Hillberry and Don Tranas monitored 2 pastures. Overall it was a very successful exercise in that the ranch Lessees gained an on-the-ground appreciation for utilization and monitoring and we are beginning to

collect data that will be extremely useful each year as we develop our rotational grazing plan. Landscape Appearance monitoring will continue each year, and as we progress, we expect to improve on technique, hopefully delivering more consistent results. We will continue to use the Range Consultants on a few pastures each year as a bit of re-training and to make sure we are achieving proper results. We will also involve Derek Trauntvein from the BLM on some pastures to make sure we have a co-operative effort and all are in agreement about the results.

The BLM is very satisfied with the program and intends to use the data collected to assist in re-evaluating pasture turn-out dates and to develop a better rotational grazing system on the ranches. As we improve livestock water distribution across the ranch, consistent monitoring will allow us to fine-tune grazing rotation and turn-out timing. It is our intention to utilize Landscape Appearance monitoring indefinitely.

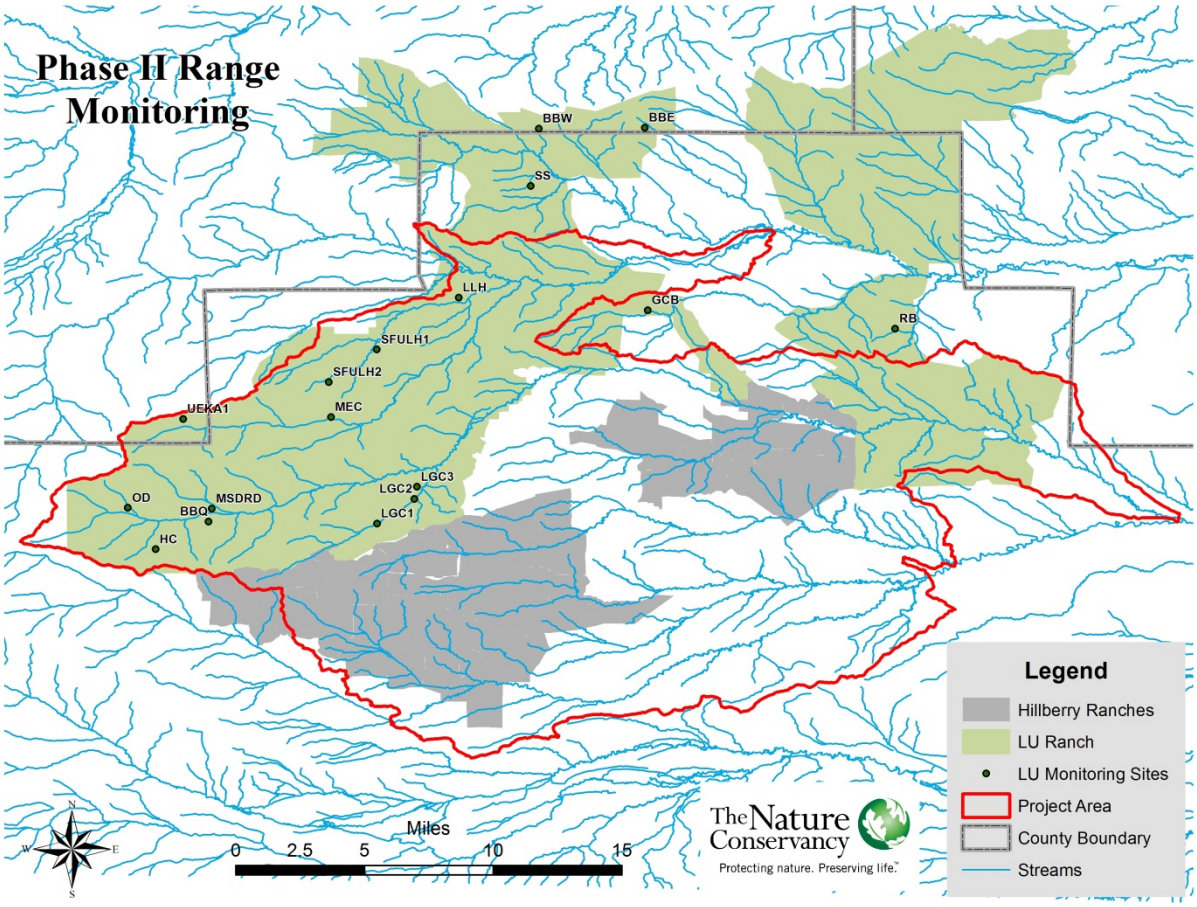


Figure 15. Range monitoring sites located on the LU Ranch and the monitoring area on Hillberry Ranches.

QUALITY ASSURANCE REPORTING

The collection and analysis of this data is consistent with the SAP developed for the project (TNC 2010). The SAP describes the proper way to collect and process data based on the *Quality Assurance Project Plan for Beneficial Use Reconnaissance Project Water Quality Monitoring* (WDEQ/WQD 2000) and the *Manual of Standard Operating Procedures for Sample Collection and Analysis* (WDEQ/WQD 2011). TNC field staff collected the data according to these procedures and the Conservancy's Stewardship Coordinator served as the quality assurance officer, checking procedures before and after data collection. Calculations for the quantitative portions of the project are located in *Appendix E: Quality Assurance/Quality Control Calculations.*

7.0 Partners

LOCAL GOVERNMENTS, INDUSTRY, ENVIRONMENTAL AND OTHER GROUPS; PUBLIC AT LARGE

Group	Involvement
LU Ranch	Collaborated on all aspects of the project to help improve wildlife habitat, water quality, range conditions, and the health of livestock operations on deeded land and federal grazing allotment.
Hillberry Ranches	Collaborated to establish range monitoring program and begin implementing BMPs on their ranches.
Hot Springs Weed & Pest	Sprayed the weed infestations in the Grass Creek Weed Management Area; provided expertise on treating weed infestations.
Marathon Oil	Provided volunteers for work-days and contributed cash match.
Round River Conservation Studies	Provided volunteer assistance with monitoring and BMP implementation.
Wyoming Conservation Corps	Provided in-kind labor.
Public At Large	Members of the public donated volunteer hours.

STATE AGENCIES

Group	Involvement
Wyoming DEQ	Assisted with planning, funding, technical training and provided informational support throughout the project
WY Game and Fish Department	Provided informational resources and technical assistance. Administered match funding from the WY Sage-grouse Conservation Fund and the Steel Jack Fencing initiative.
WY Department of Agriculture	Assisted with development of the range monitoring plan
Wyoming Conservation Corps	Worked for a week cutting conifers in riparian areas and helped develop a spring.
WY Wildlife and Natural Resource Trust Fund	Provided match funding.
University of WY Extension	Assisted with development of the range monitoring plan and taught the range monitoring workshop
Wyoming Honor Farm	Helped build riparian fences on Grass Creek and plant willows

FEDERAL AGENCIES

Group	Involvement
Natural Resource Conservation Service	Provided technical training, assistance with water quality and range monitoring, help with BMP implementation, and assistance at project work days
Bureau of Land Management	Crews assisted with conifer control on Left Hand Creek

8.0 Information and Education

The Nature Conservancy hosted another Wyoming Conservation Corps (WCC) crew in 2012. The WCC, a service organization following in the tradition of the Civilian Conservation Corps, provided a crew that helped perform conifer control along Little Grass Creek, initiated development of the WCC spring on Left Hand Creek, and participated in an LU Ranch volunteer day on May 31, 2012, contributing 640 work hours to the project.

The aforementioned LU Ranch volunteer day saw the participation of thirty-two volunteers, including TNC staff and supporters, WCC crewmembers, and Marathon Oil employees. Volunteers worked to remove a dilapidated barbed-wire fence. The fence impeded wildlife migration and posed collision risks for sage grouse in the area. The volunteers also learned about the benefits of the project as well as future project goals.

On June 3, 2013 TNC held another field day in partnership with the Hot Springs County Weed and Pest District to work on weed infestations. In addition to HSCWP and TNC staff, a handful of volunteers attended, including a former University of Wyoming professor, with a particular interest in biological control of weeds. The goal of the volunteer day was to collect and redistribute specimens of the rosette weevil (*Trichosirocalus horridus*), to control non-adjoining populations of musk thistle (*Carduus nutans*). Participants did not find the weevil, so the Weed and Pest Crew used the day to spray other weed infestations on the ranch, while remaining volunteers removed two sections of fence that posed risks to wildlife.

TNC staff showcased the Grass Creek project at the 2013-15 Cody Wild West River Fest events. The annual festival, which was previously funded by the WDEQ 319 program, highlights the importance of water quality for recreation, fisheries, habitat, and livestock operations. Project handouts were distributed to many attendees of the annual events. Each year at the festival, participants are able to visit many booths that demonstrate water quality monitoring and improvement practices, many of which are used in this project.

9.0 Complications

Road and stream-crossing repairs have been completed periodically throughout the project period and have sometimes added noticeably to stream turbidity. Likewise, logging operations to remove pine beetle killed tress have been ongoing on Grass Creek and tributaries since 2011. While we are not able to determine the quantity of sediment inputs in the stream due to logging and road-building, it is our hope that our work to reduce bank erosion due to livestock is not

being overwhelmed by these and other inputs outside our control, and that our work will continue to positively impact sediment loading in the project area.

Vegetation identification

Willow planting also had its challenges on Grass and Little Grass Creeks. More trees would have been planted on Grass Creek, but the substrate along the stream bank rendered the water jet stinger planting tool ineffective. A hard layer of rock kept the pressurized water from penetrating deep enough to allow willow survival. The rockiness also kept the soil from filling back in around the stems.

Turbidity sampling was discontinued in Phase II of the project. In 2012 monthly samples were collected in solid bottles, but still did not yield viable results. Sediment was still falling out of solution and would not re-suspend with manual shaking. These samples only indicated stream turbidity at four points during the year; there was no way to account for daily changing causes of turbidity like precipitation events, livestock, or wildlife-caused turbidity increases.

Additional types of data would be helpful in determining certain causes of declining stream health. Precipitation and flow data for each stream at various points over the life of the project would have been helpful, but were not feasible due to financial and staffing constraints. The decreased particle sizes seen at most of the sites in 2013 indicate that more sediment was moving through the system, but our data does not show how. Possibilities include increased stream flows from storm activity or inputs from other activities like logging, ATV recreation, and camping (the ranch allows public hunting and recreation).

We established our water quality monitoring sites before selecting site for BMP implementation; those monitoring sites may not all have located in close enough proximity to the BMP implementation sites to accurately assess the impacts of the BMPs. The Rosgen monitoring sites, in areas where BMPs were implemented, should have visible and measureable decreases in sediment loading because livestock should be utilizing the riparian areas less. Our temperature loggers were not located in sites targeted for revegetation, so even local stream temperature reductions due to the BMPs (which is all we could reasonably hope for at this point) are likely not reflected in our monitoring data sets.

10.0 Recommendations

The Phase III grant that TNC began implementing in 2014 is already covering many of the future activities that TNC would recommend completing.

1. Continued Monitoring. Two additional years of water quality data will be collected with the project ending in 2015. This should allow sufficient time to monitor BMPs implemented for the project. Aspen regeneration will be monitored again in 2016. Survival of the willows planted in Phase II will be monitored in Phase III as well.
2. Conifer Control. Lack of fire has allowed conifers to encroach into the riparian areas. Additional conifer control was conducted in 2015 and will be reported in the Phase III report.

3. Noxious Weed control. Weeds that increased as a result of some of the conifer control conducted in Phase II may require additional attention in the future.
4. Future Monitoring. Additional monitoring several years beyond Phase III would help demonstrate the impact of the BMPs implemented for this project.

11.0 Financial Summary

Task #	Task Title	319 or 205(j) Funds Expended	Nonfederal Match Expended	Total NPS Expenditures	Other Federal Funds Expended
1	Administration	$1,214.52	$10,976.46	$12,190.98	$0.00
2	BMP Implementation	$116,484.01	$82,977.66	$199,461.67	$0.00
3	Plant Control	$36,754.38	$37,055.51	$73,809.89	$0.00
4	Monitoring	$50,571.80	$3,019.55	$53,591.35	$0.00
5	Revegetation	$66,586.90	$1,273.34	$67,860.24	$0.00
	TOTALS	$271,611.61	$135,302.52	$406,914.12	

OTHER SOURCES OF FUNDS

Contributor	Amount
Marathon Oil	$20,000
Wyoming Wildlife and Natural Resource Trust	$73,541
LU Ranch (cash and in-kind)	$20,938 + $12,100
Volunteer labor	$1,067.22

12.0 Attachments

LIST OF APPENDICES

- Appendix A: Monitoring Results for the Grass, Enos and Left Hand Creek Nonpoint Source Reduction Project.
- Appendix B: Compilation of Raw Monitoring Data 2010-2013
- Appendix C: LU Ranch Range Monitoring Data 2010-2013
- Appendix D: Hillberry Ranches Range Monitoring Data 2012-2013
- Appendix E: Quality Assurance/Quality Control Calculations 2010-2013

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